UNIVERSITY OF ALBERTA

Effects of Cattle Grazing on Breeding Wetland Birds in the Aspen Parkland of Alberta

by

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ABSTRACT

The cattle industry in central Alberta is experiencing rapid growth. Effects of cattle grazing on birds that breed in wetlands of the Aspen Parkland are poorly understood. To understand some of the ecological consequences of cattle grazing, I evaluated impacts of grazing intensity on species richness, nest density and nest survival of wetland birds across 181 wetlands in the Aspen Parkland of Alberta in 2001 and 2002. Species richness of breeding wetland birds increased in relation to residual cover of upland vegetation surrounding wetlands. Blackbird nest density was highest in wetlands moderately impacted by cattle, however nest survival declined as grazing impacts increased. Nest densities of other songbirds were lowest in wetlands adjacent to idled or lightly grazed uplands, however nest survival increased in relation to residual cover of upland vegetation and growth of emergent vegetation. Waterbirds nested at higher densities in moderately grazed wetlands in native pastures, but nest survival increased in relation to residual cover of upland vegetation. Although light to moderate grazing may benefit species richness and nest density of some wetland birds, reduced nest success in wetlands impacted by cattle suggests that managers should pursue management practices that minimize cattle activity in wetlands.

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1.0 INTRODUCTION

The Aspen Parkland (hereafter Parkland) is a transitional ecotone within the Prairie Pothole Region (PPR) that bridges the Boreal forest and the mixed-grass prairies (Fig. 1). Historically, vegetation in the Parkland was dominated by wide expanses of plains rough fescue (*Festuca hallii* (Vasey) Piper) grasslands, interspersed with stands of trembling aspen (*Populus tremuloides* Michx.) (Olson 1994). Following European settlement, the landscape was greatly altered by fire suppression, the removal of plains bison (*Bison bison bison*), and extensive conversion of native habitat to agriculture (Olson 1994). Of the 10.5 million hectares occupied by the Parkland in Alberta, native grasslands have largely been replaced by annual cropland (39%), tame pasture/hay (29%) and urban development (7%; Statistics Canada 2001). Substantial loss and alteration of wetlands from drainage and annual tilling have also occurred. Approximately 61% of wetlands in the Parkland have been lost since settlement (Schick 1972, Strong et al. 1993).

Although they occupy a small portion of the landscape, wetlands in the Parkland provide critically important breeding habitat for waterfowl and other migratory birds (Kantrud and Stewart 1984; Knopf et al. 1988; Euliss et al. 1999). Broad soil moisture gradients and fluctuations in water levels promote increased complexity of vegetation in Parkland wetlands, which in turn, provides nesting habitat to a variety of bird species (Weller and Spatcher 1965; van der Valk and Davis 1978; Stauffer and Best 1980; Douglas et al. 1992). Compared to other habitats, seasonal and semi-permanent wetlands support the highest density and diversity of birds because of greater structural heterogeneity (Kantrud and Stewart 1984, Prescott et al. 1995). Although predators may be attracted to wetlands in patchy landscapes (Burger et al. 1994), birds can still find

refuge from mammalian predators in wetland habitats when adjacent cover is well managed (Pasitschniak-Arts and Messier 1995; Lariviere and Messier 1999). For some

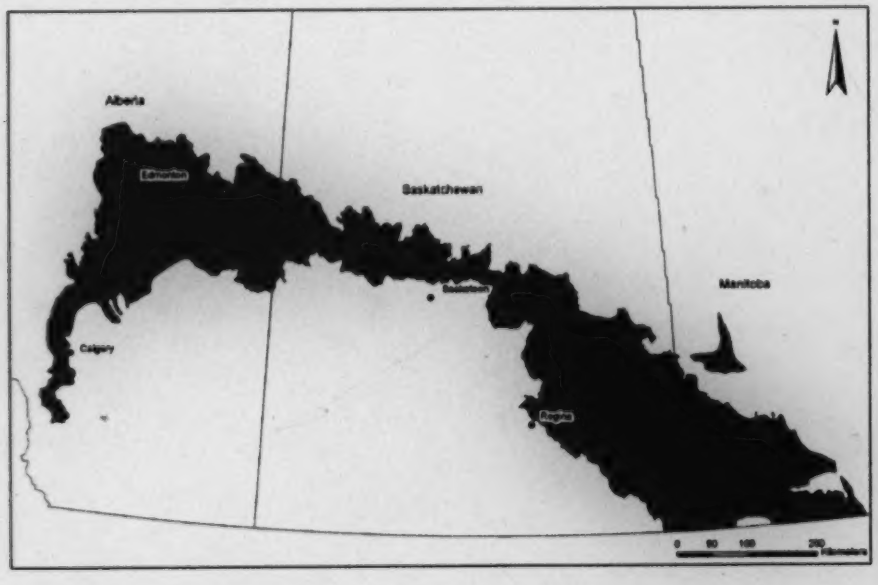

Figure 1: Aspen Parkland ecoregion (Source: Ducks Unlimited Canada)

birds, nesting over deep water offers the greatest protection from land-based predators (Johnson and Dinsmore 1986, Sutherland and Maher 1987, Barnes and Nudds 1990, Schaffer 1996). In addition to providing nesting cover, wetlands offer abundant food resources such as aquatic insects, submergent and emergent vegetation, and seeds to breeding wetland birds (Swanson and Duebbert 1999; Euliss et al. 1999). Furthermore, because these habitats offer food resources and protection for offspring, wetland availability is an important habitat consideration for nest site selection for several upland-nesting bird species (Swanson and Duebbert 1989; Krapu et al. 1997).

Alberta's cattle herd is the largest in Canada, totalling 5.7 million animals (Statistics Canada 2001). High demand for forage resources within the Parkland has resulted in chronically high stocking rates relative to pasture production capabilities (Chorney and Josephson 2000). Typically, high rainfall patterns throughout the growing season result in predictably high herbage production in the Parkland (e.g. Bork et al. 2001). Because of this trend, cattle producers in the Parkland have commonly maintained high stocking rates, with the expectation that forthcoming rainfall will replenish previously utilized forage. Although this type of management might yield higher beef production, the consistent over-utilization of available herbage results in unfavourable habitat conditions for wildlife (Dwyer et al. 1984, Fleishner 1994). Low residual cover, deficient litter accumulation, and limited plant growth associated with chronic overgrazing in uplands contribute to declines in avian diversity (Gjersing 1975, Kantrud 1981), reduced nest density (Bowen and Kruse 1993, Fondell and Ball 2004), and reduced nest survival (Kirsch 1969, Fondell and Ball 2004) of wetland and grassland bird communities.

Despite recent drought in 2001 and 2002, and discovery of Bovine Spongiform Encephalopathy in 2003, growth in the cattle industry of Alberta continues. Because of high potential for conversion of cropland to pasture and hayland, this growth is occurring primarily in the Parkland (Ducks Unlimited Canada, unpublished report). Expansion of the beef industry in the Parkland has already resulted in conversion of approximately 1.2 million ha of cropland to pastureland and hayland since 1976 (Statistics Canada 2001). Landuse conversion may be beneficial to bird communities because of increased area of perennial cover (i.e. non-cropped land; McMaster and Davis 2001; Fletcher and Koford

2002; Stephens et al. 2003). Theoretically, this should provide additional breeding habitat for birds, provided this cover is well managed (Stephens et al. 2003). Furthermore, previously drained or tilled wetlands within these converted landscapes may be restored to wet conditions through cessation of cropping activities resulting in additional breeding habitat for wetland birds.

Within some cropland however, there currently exists islands of marginally productive land or wetland habitats that remain idle and are beneficial to wildlife. If cropland surrounding this habitat is converted to pasture, these islands of idled habitat will probably be included in pastures and may be gradually degraded through overgrazing. Although conversion of cropland to perennial cover may be attractive to birds, their reproductive success may decline if the quality of habitat is degraded to the extent that it reduces nest success.

Wetlands may be particularly sensitive to impacts of heavy grazing. The timing and extent of wetland forage use by cattle is highly variable (Anonymous 2001, Asamoah et al. 2003), and depends on several factors including management and control of livestock (Marlow and Pogacnik 1986), seasonal changes in forage quality and palatability (Marlow and Pogacnik 1986, Holechek et al. 1998, Asamoah et al. 2004), type of grazing system (Severson and Boldt 1978), quality and quantity of wetland forage in relation to upland forage (Skovlin 1984), availability and location of alternate water sources and shade (Anonymous 2001), mineral and feed supplements (Holechek et al. 1998), and season and duration of grazing (Ehrhart and Hanson 1997). Regardless of this variability however, cattle spend a disproportionate amount of time in wetland habitats

thereby increasing the potential for habitat degradation by consuming wetland vegetation and trampling soft substrates (Fitch and Adams 1998, Anonymous 2001, Asamoah 2002).

Given the importance of the beef industry in western Canada and the United States, and potential impacts on migratory birds within the PPR, much research on the subject has already been conducted, particularly in the mixed-grass prairie. Several authors have studied impacts of grazing on birds (especially waterfowl) that nest in upland habitats (e.g. Kruse and Bowen 1996, Gjersing 1975, Fondell and Ball 2004, Kirsch 1969, Kantrud 1981, Prescott et al. 1998). Although the potential negative impacts of grazing to wetland and riparian birds has been recognized (Ducks Unlimited Canada unpublished, Fitch and Adams 1998, Anonymous 2001), most research into grazing effects on riparian birds has focussed on stream bank habitat in prairie ecosystems (e.g. Taylor 1986, Knopf et al. 1988, Popotnik and Giuliano 2000). In contrast, very little research has been conducted on effects of cattle grazing on wetland birds in the Aspen Parkland.

To address concerns surrounding potential impacts of grazing intensity on migratory birds, I began a 2-year investigation of the effects of cattle grazing on wetland bird communities in Alberta's Aspen Parkland in 2001. I was interested in determining how grazing intensity impacted wetland birds, and more specifically, what components of grazing (e.g. reduced height and density of upland and wetland plants, disruption of nesting habitat, etc.) contributed to variation in species richness, nest density and nest survival of wetland birds. Therefore, the objectives of this study were to investigate 1) breeding species richness (BSR), 2) nest density (ND) and 3) nest daily survival rates (DSR) of wetland birds in relation to cattle grazing intensity.

2.0 STUDY AREA

Within Alberta, the Aspen Parkland occupies the central portions of the province (50-54°N Latitude and 110-114°E Longitude; Fig. 1). Precipitation averages 466 mm annually (Environment Canada 1996) with approximately 62% falling between May and August (Strong and Leggat 1992). Although groundwater tables are an important and complex feature of wetland hydrology, Parkland wetlands receive most of their annual recharge during spring melt events (Winter 1989). Evaporation during spring and summer is partially offset by occasional rainfall.

Below average snowfall, combined with infrequent and minimal rainfall caused drought conditions over much of Alberta in 2001. Agriculture Canada listed annual precipitation in 2001 as approximately 60-85% of normal (Agriculture and Agri-Food Canada 2001). Despite the drought of 2001, wetlands received a considerable amount of recharge in spring 2002, due to above-average (150-200% of normal) snowfall in late March and early April (Ducks Unlimited Canada unpublished report). This recharge was not sustained however, as the lack of spring and summer rains failed to counter the effect of extreme drought during the previous year. The drought conditions evident in upland habitats in 2001 were strongly exacerbated by continued drought during 2002, which resulted from a 60% deficit in average rainfall.

3.0 METHODS

Data were collected concurrent with a study that examined effects of cattle grazing on upland nesting waterfowl production (Warren 2004). Data on pasture vegetation characteristics and wetland classification herein were, with few exceptions, collected by

J. Warren and are gratefully used with permission. Landscape and other remotely-sensed data were derived jointly by the two projects.

3.1 Site Selection

Between 2001 and 2002, 181 wetlands were surveyed in 74 pastures within the Aspen Parkland of central Alberta. To increase spatial replication, I tried to select new wetlands and pastures in each year. However, twelve wetlands were included for study in both years due to limited availability of alternate sites. Study sites were located in both private and public pastures. Prior to each field season, 8 clusters (16 total; Fig. 2), each containing approximately 6 pastures representing 6 grazing treatments differing by grass type (tame and native/naturalized) and grazing intensity (idle/low, moderate and heavy) were identified. Tame pastures were generally seeded to tame forage, and were dominated by stands of introduced graminoids (e.g. *Bromus* spp., *Phleum pratense* L.,

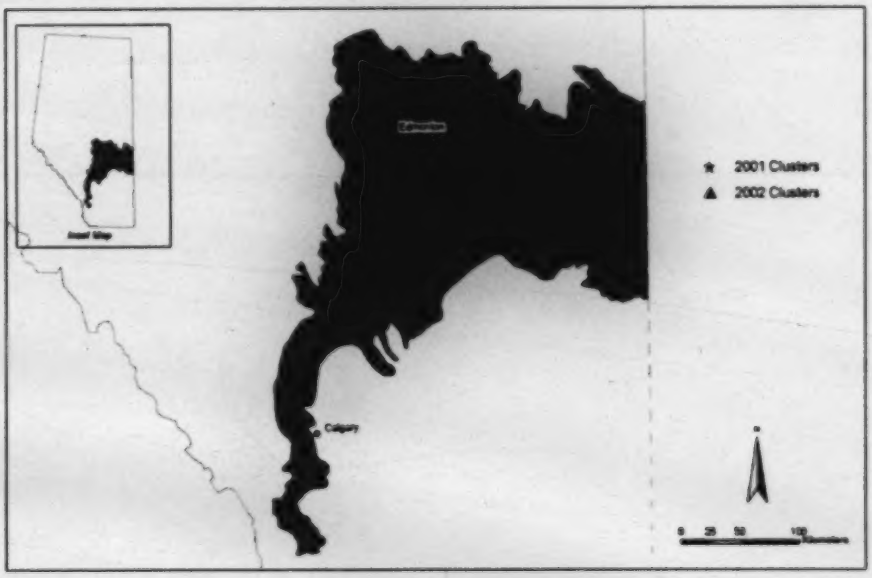

Figure 2: **Cluster locations in 2001 and 2002 in the Aspen Parkland ecoregion of Alberta.**

Agropyron spp.) and forbs (e.g. *Medicago sativa, Trifolium hybridum*).

Native/naturalized (hereafter, native) pastures were identified primarily by presence of a substantial shrub and forb community, but also by presence of native upland graminoids (e.g. rough fescue). Naturalized pastures were often dominated by introduced graminoids (e.g. *Poa pratensis* L.), however encroachment of shrubby species (e.g. *Elaegnus commutate, Rosa acicularis, Ribes* spp., *Symphoricarpos* spp.) made these pastures structurally similar to native stands. Each pasture had at least 32.4 ha (80 acres) of grassland, and was usually 64.8 ha (160 acres) in total area. Because of differences in pasture productivity and also because my study focused on birds and nesting cover, I characterized grazing intensity based on residual vegetation rather than cattle stocking rates.

Within each pasture, 1-3 wetlands were randomly selected as study sites. All selected wetlands were relatively small ($\bar{x}$ = 1.13 ha), seasonal or semi-permanent basins (Class III and IV, respectively; Stewart and Kantrud 1971) that 1) contained water in late April of the study year, and 2) were visually representative of grazing intensity in surrounding uplands. Wetlands were classified by water permanency (PCLASS) and cover type characteristics (COVER) as defined by Stewart and Kantrud (1971).

3.2 Point Count Surveys

I measured breeding species richness of wetland birds using 50 m fixed radius point counts that included wetland and adjacent upland habitat (Hutto et al. 1986; Dale 1993; Dale et al. 1997). Point counts lasted for 5 minutes and were followed by 30-second call response surveys (Gibbs and Melvin 1993) for sora (*Porzana carolinus*), pied-billed

Table 1: Independent variables, treatments, and covariates describing trends in breeding species richness, nest density and nest daily survival rates of birds occupying wetlands in the Aspen Parkland.

Covariate	Description	Covariate	Description
Non-Habitat			
BBNESTS	Total blackbird nests	SEARCH	Area (ha) of habitat searched at each study site
DATE	Elapsed days following first nest initiation in each guild	SQRTDISTASP	Square root distance (m) to nearest aspen stand
YEAR	Study year; 2001 or 2002	SQRTDISTWET	Square root distance (m) to nearest seasonal or semi-permanent wetland
		WAREA	Total wetland area (ha)
Nest Site		WET	Flooded (1) or dry (0) basin at end of breeding season
NCP	Evidence of cattle presence (1) / absence (0) ≤4m of nest	WINTENSE	Categorical measure of wetland grazing intensity
NDEPTH	Depth of water at overwater nest site	WTREND	Difference in WVOR from May to July
NDISTDRY	Distance to shore (overwater nests)	WVOR	Wetland visual obstruction readings
NHGT	Height (cm) of nest above ground / water		
NMAX	Maximum height of vegetation within 25cm of nest site	**Pasture**	
NTYPE	Waterbird nest type; platform (pl) or grassland (gr)	CP	Cattle presence (1) / absence (0) in pastures
NVOR	Average visual obstruction reading at nest site	GRTYPE	Pasture type; native/naturalized (N) or tame grasses (T)
		PASTSCR	Pasture health assessment score
Wetland		PINTENSE	Pasture grazing intensity; idle/low, (L), moderate (M), or heavy (H)
BARE	Proportion of emergent zone occupied by bare ground	PMAXHGT	Average maximum pasture plant height measurements
CAI	Cattle activity index describing disruption of emergent habitat	PROPWET	Proportion of flooded basins within each pasture in July
COVER	Wetland cover type (type 1, 2, or 3)	PTREND	Difference in PVOR from May to July
COVSHB	Proportion of wetland perimeter occupied by shrubby habitat	PVOR	Pasture visual obstruction readings (residual cover)
COVTRE	Proportion of wetland perimeter occupied by aspen	WDDENSE	Proportion of pasture area occupied by woodland habitat
DISTASP	Distance (m) to nearest aspen stand	WETDENSE	Proportion of pasture area occupied by wetland habitat
DISTWET	Distance (m) to nearest seasonal or semi-permanent wetland		
LNWAREA	Natural log of wetland area (ha)	**Landscape**	
MAXHGT	Normalized maximum plant height of wetland vegetation	GL1-4	Proportion of grassland area occupying 1 – 4 km buffer radii
NPLANT	Number of plants species occupying ≥5% of any emergent zone	NORTH	Latitudinal gradient; UTM northing
OWTR	Area (ha) of open water	PC1-4	Proportion of total perennial cover occupying 1 – 4km buffer radii
PCLASS	Wetland permanency class; seasonal (3), or semi-permanent (4)	WO1-4	Proportion of woodland habitat occupying 1 – 4 km buffer radii
PCTOPEN	Proportion of wetland area occupied by open water		

grebe (*Podilymbus podiceps*), American bittern (*Botaurus lentiginosus*), and horned grebe (*Podiceps auritus*). An initial survey was conducted prior to each point count to record the presence of large birds (waterfowl, herons, etc.) that typically flush when disturbed. During initial surveys, point counts, and call response surveys, all species observed or heard were recorded. Surveys occurred within 4 hours following dawn in absence of inclement weather (i.e. high wind, fog or heavy precipitation). Point counts commenced in late May when most species had completed spring migration. A second round of point counts occurred approximately 3 weeks later in late June / early July. Species detected during point counts were separated into casual occupants (observed once during surveys), probable breeders (observed twice during successive surveys), and confirmed breeders (nests observed during subsequent nest searching; see below). Analyses for breeding species richness included only the data for probable and confirmed breeders.

3.3 Nest Density and Nest Fate Monitoring

Because of differences in nesting ecology of birds, nests monitored during this study were placed in one of three nesting guilds: blackbirds, other songbirds, and waterbirds (Table 2). Blackbirds are typically colonial nesters that build conspicuous nests on tall emergent plants such as cattail or bulrush. However, other songbirds included in this study typically nest discretely in grasses or at the base of small shrubs. Although some waterbird nests were relatively visible when placed over water (e.g. horned grebe), the majority of nests within this group were well concealed in dry or wet emergent cover. Waterbirds were separated from songbirds primarily because of the large difference in concealment requirements.

Following point counts, investigators paired up to search for bird nests within wetlands and wetland margins. Searches occurred between 09:00 and 14:00 to ensure the highest probability of encountering laying or incubating females (Gloutney et al., 1993, Pietz and Granfors 2000). Multiple searches (i.e. 2 in 2001 and 3 in 2002) occurred, approximately 3 weeks apart, starting in late May and lasting until few new nests were initiated in late July. Nest searching in dense emergent vegetation was done on foot whereby two investigators walked side by side (3-4 m apart) using two long sticks (approximately 2 m long) each to brush vegetation (Klett et al. 1986). Once birds were flushed, investigators would intensively search for nests. Searches within flooded emergent vegetation (e.g. Cattail [*Typha spp*]) relied primarily on direct visual observation of nests or observation of a female bird leaving a suspected nest site. Bird species identification was usually determined by direct observation of the flushed bird or through evidence collected at the nest (e.g. egg size and color, breast feathers at nest bowls, physical characteristics of the nest). Nest locations were recorded within the wetland and marked using a small piece of flagging tied to a willow or bamboo stake exactly 4 m away. A compass was used to exactly mark the direction of the flagged stake in relation to the nest. I estimated the age of nests using ≥1 eggs or young (see following paragraph) and measured nest site vegetation. Nests were revisited periodically (4-5 day intervals for songbirds [Martin and Geupel 1993; Martin et al., 1997], 7-8 day intervals for waterbirds [Klett et al. 1986]) until nesting fate was determined. Nests were considered successful if one or more young left the nest. Unsuccessful nests were those containing eggs or unfledged nestlings that were either abandoned or completely destroyed by predators. Nests for which fate or cause of failure was unknown (n = 45;

Table 2: Nesting guilds and number of nests observed in 2001 and 2002.

Common Name	Scientific Name	2001	2002
BLACKBIRDS			
Common Grackle[a]	*Quiscalus quiscula*		1
Red-winged Blackbird[a]	*Agelaius phoeniceus*	86	162
Yellow-headed Blackbird[a]	*Xanthocephlaus xanthocephalus*	28	15
Total		114	178
OTHER SONGBIRDS			
Alder Flycatcher[b]	*Empidonax alnorum*		1
Clay-colored Sparrow[b]	*Spizella pallida*	3	41
Common Yellowthroat[c]	*Geothlypis trichas*		1
LeConte's Sparrow[c]	*Ammodramus leconteii*		1
Lincoln's Sparrow[c]	*Melospiza lincolnii*		5
Savannah Sparrow[c]	*Passerculus sandwichensis*	8	33
Song Sparrow[c]	*Melospiza melodia*		9
Vesper Sparrow[c]	*Pooecetes gramineus*		1
Total		11	92
WATERBIRDS			
American Coot[d]	*Fulica americana*	6	14
Black Tern[d]	*Chlidonias niger*	16	11
Blue-winged Teal[e]	*Anas discors*	5	10
Canvasback[e]	*Aythya valisineria*	1	
Gadwall[e]	*Anas strepera*	1	1
Horned Grebe[e]	*Podiceps auritus*	3	1
Lesser Scaup[e]	*Aythya affinis*	2	4
Mallard[d,e]	*Anas platyrynchos*	6	8
Northern Shoveler[e]	*Anas clypeata*	2	9
Redhead[d]	*Aythya americana*		3
Ruddy Duck[d]	*Oxyura jamaicensis*	8	1
Sora[e]	*Porzana carolina*		2
Total		50	64

[a] Nests elevated in cattail or bulrush.
[b] Nests placed slightly above ground level in base of shrub.
[c] Nests concealed in grassy cover.
[d] Nests placed over water.
[e] Nests placed over dry ground.

predominantly blackbirds) were not included in nest survival estimates.

Eggs of songbirds and waterfowl were aged using methods described by Lokemoen and Koford (1996) and Weller (1956), respectively. A floatation method similar to that described by Westerskov (1950) was used to estimate incubation stage for some waterfowl eggs where embryonic development could not be directly viewed by candling (i.e. due to thick shells).

Songbird nestlings were aged using a combination of techniques. The most accurate method for aging nestlings was based on the actual hatch date and nestling age was simply the number of days post-hatch. In absence of hatch date information, nestling development of house sparrows (*Passer domesticus*) (Baicich and Harrison 1997) was used to estimate developmental stages of songbirds. Successful blackbird and other songbird nests (i.e. ≥1 fledged nestlings) were determined by a combination of methods. The best method was observation of flight capable nestlings on or near the nest, combined with sightings of fledglings near the nest site in subsequent days. The presence of feces at and below the nest bowl's edge, combined with compressed nesting material provided strong evidence of perching and therefore successful flight by fledglings (Martin et al. 1997).

3.4 Nest Site Characteristics

When nests were initially located, maximum plant height (NMAX) and visual obstruction (NVOBS; 2002) of vegetation within 50 cm of the nest bowl were recorded. Physical attributes of the nest site were also recorded including nest height (NHGT), distance to dry ground (NDISTDRY), and depth of water at nest site (NDEPTH). Presence or absence of recent cattle activity (i.e. hoof prints, feces) within 4 m of the nest site (NCP) was also recorded.

3.5 Vegetation Monitoring

I recorded visual estimates of grazing intensity and measured several vegetation structure and cover parameters to orient wetland and upland communities along a continuum of grazing intensity. In each field season, several randomly selected points within pastures (20 in 2001; 30 in 2002) were visited in early May to quantify residual

cover of upland vegetation using visual obstruction readings (PVOR; Robel et al. 1970) and maximum height (PMAXHGT) measurements. Each location was revisited in late July to quantify the positive or negative structural change (i.e. to reflect grazing pressure) that occurred during the breeding season of wetland birds. Furthermore, pasture scores (PASTSCR) derived from Range/Pasture Health Assessments (Adams et al. 2000) were used as alternate predictors of BSR, ND and DSR.

Grazing intensity for each wetland was assessed using maximum plant height (MAXHGT) measurements, the proportion of bare ground (PBARE) in emergent zones (Daubenmire 1959) and in 2002, visual obstruction readings (WVOR; Robel et al. 1970). To compare grazing intensity among plant communities with differing growth potential (e.g. sedges vs. cattail), MAXHGT and WVOR were normalized between 0 and 1 by dividing individual measurements by the tallest measurement recorded in each emergent community across all study sites. Wetland vegetation was measured at random points in early May, and again in late July to quantify positive or negative structural change (WTREND). Vegetation measurements were averaged to provide one estimate for each variable in upland and wetland plant communities.

Midway through each growing season (June), I estimated the amount of recent cattle activity using the following 4 point scale:

1 = 0 hoof prints per square meter
2 = 1-5 hoof prints per square meter
3 = 6-10 hoof prints per square meter
4 = >10 hoof prints per square meter

Cattle activity indices were recorded within each wetland plant community and at each ordinal direction (north, south, east, west) around wetlands and then combined to yield an average score (CAI) per wetland.

As an index of structural heterogeneity, I recorded the number of plant species (NPLANT) present in each wetland near the end of each field season. One investigator slowly walked though emergent communities and recorded each plant species estimated to occupy at least 5% of the area within each water permanence zone (plant community). Following this, the proportion of wetland fringe immediately surrounded by shrubby (COVSHB) and tree cover (COVTRE) was estimated (Naugle et al. 1999) using the following classifications:

0 = shrubs/trees not present
1 = 0-5% of perimeter occupied by shrub/tree
2 = 5-25% of perimeter occupied
3 = 25-50% of perimeter occupied
4 = 50-75% of perimeter occupied
5 = 75-95% of perimeter occupied
6 = 95-100% of perimeter occupied.

All wetlands (including study sites and other wetlands) within each pasture were visited in late July to collect additional covariates that might have influenced distribution patterns of birds. Each wetland was characterized by water permanence (Stewart and Kantrud 1971), cover type, and presence/absence of standing water. Wetland perimeters were delineated on aerial photographs and were included in Geographic Information Systems (GIS) modeling, described below.

3.6 GIS Modelling

Study wetlands were digitized from recent (≤ 5 years) aerial photographs (scale = 1:20,000). Total wetland area (WAREA), wetland perimeter (PERIM), area of emergent cover (EMERG), and area of open water (OWTR) were calculated using ArcView GIS software. Pastures were also digitized from aerial photographs to estimate total pasture area (PAREA), wetland density (WETDENSE), and woodland density (WDDENSE).

The proportion of wetland habitat remaining wet through July (PROPWET) was estimated by dividing the area of wet basins (determined during wetland classification) by total wetland area in each pasture. Because adjacent woodlands and neighbouring wetlands might have influenced the attractiveness of wetlands to birds, distance between study wetlands and nearest aspen stands (DISTASP) and distance between study wetlands and the nearest seasonal or semi-permanent wetland (DISTWET) were also estimated using ArcView.

To examine landscape effects on BSR, ND, and DSR, land cover data were obtained from Agriculture and Agri-Food Canada that were derived from 30 m resolution Landsat^{TM} satellite imagery (Agriculture and Agri-Food Canada 1995). For each site, the proportion of perennial cover (i.e. non-cropped land) occurring at 1 – 4 km buffers (PC1-4), measured from the geographic center of each pasture was quantified. Perennial cover was further subdivided to identify proportions of grassland area (GL1-4) and woodland area (WO1-4) within identical buffer radii. The proportion of wetland habitat occupying 1 – 4 km buffers was not derived for this study using remote sensing, due to inadequate resolution of imagery to detect small basins.

4.0 DATA ANALYSIS

4.1 General Approach

Information theoretic techniques (e.g. Burnham and Anderson 1998) were used to evaluate *a priori* and exploratory models developed to describe trends in BSR, ND and DSR of wetland birds. The relative strength provided by parameters within each model was evaluated by ranking models using Akaike's Information Criterion corrected for small sample size (AIC_c; Burnham and Anderson 1998). Akaike's Information Criterion

uses the principal of parsimony in selecting models that include only those parameters or interacting parameters that explain a substantial portion of variation within the data, while eliminating those parameters that provide little or no information (Burnham and Anderson 1998). Akaike's Information Criterion corrected for small sample size was calculated for each candidate model as:

$$AIC_c = [-2(\text{loglikelihood}) + 2K] + [2K(K+1)]/(n-K-1)$$

where K represents the number of parameters estimated by the model and n is the sample size. Akaike's Information Criterion calculations inherently include a penalty for inclusion of extraneous parameters (Burnham and Anderson 1998). The highest ranking models within a suite of candidate models demonstrate low AIC_c values and are best described by subtracting minimum AIC_c values from each AIC_c score calculated for each candidate model (i) present within each suite (i.e. $\Delta AIC_c = AIC_{ci} - \text{min}AIC_c$; Burnham and Anderson 1998). The best model therefore has a ΔAIC_c of 0.00. Competing models have similarly low scores that fall within ΔAIC_c values of 2.00 (Burnham and Anderson 1998). Further evidence to support the strength of individual models was determined through calculation of normalized relative model weights (Akaike weights [ω]) according to the formula:

$$\omega_i = [\exp(-0.5 \cdot \Delta AIC_c)_i] / [\sum \exp(-0.5 \cdot \Delta AIC_c)_s]$$

where s represents the entire suite of models in which model i appears. Because I was concerned about model uncertainty and the strength of individual parameters, I also calculated the average weight ($\omega\theta$) of each predictor occurring in top-ranked models across all candidate models within a given suite. Average model weights were calculated as:

$$\omega\theta = \sum \omega_i / N_s$$

where N_s indicates the number of models in a given suite in which the parameter of interest, θ, occurs.

The development of *a priori* models included a thorough review of existing literature to identify primary habitat variables that contribute to variation in BSR, ND, and DSR. In addition, I considered several covariates that may explain observed variation within data across grazing regimes. Selected interactions (e.g. GRTYPE*PINTENSE) or quadratic models (CAI*CAI) were considered when previous experience or evidence suggested such a relationship might exist.

4.2 Breeding Species Richness

I modelled species richness of breeding wetland birds in relation to several habitat variables using generalized-linear models, assuming a negative-binomial distribution and a log-link function in PROC GENMOD (SAS Institute Inc. 2001). With a negative binomial dispersion, the distribution of count data is described by the mean ($\bar{x}$) and a dispersion parameter (k). The parameter k describes the degree of clumping in point count data (White and Bennetts 1996). The negative binomial distribution is flexible enough to accommodate different values of k (i.e. different clumping patterns), and can therefore be used on highly skewed data distributions that occur with point counts (Boyce et al. 2001). Poisson distributions can also be used for skewed samples, but it requires that the mean be approximately equal to the variance; an assumption that is relaxed by the negative binomial (White and Bennetts 1996).

Breeding species richness was modelled using 180 wetlands distributed across the spectrum of grazing intensity in the Parkland. Because I sampled 2-3 wetlands within

each of several pastures, I first confirmed the independence of BSR estimates across multiple wetlands within a single pasture ($r = 0.20$) using generalized estimating equations (GEE) through PROC GENMOD (SAS Institute Inc. 2001).

Due to uncertainty in the scale at which birds respond to habitat conditions (Fairbairn and Dinsmore 2001b), I developed *a priori* models for both wetland and pasture scales. Recognizing that wetland size will have a positive, but diminishing effect on BSR (Brown and Dinsmore 1986), I used the natural log of total wetland area (LNWAREA) as a variable that was common to all models in the wetland suite. Eleven wetland habitat covariates were included in various combinations within candidate models, as were 3 separate measures of grazing intensity and cattle activity. Wetland birds probably use a number of cues to assess habitat quality (Fairbairn and Dinsmore 2001a). Therefore, in addition to modelling BSR at the wetland scale, I also included 3 habitat variables and 3 grazing variables, measured at the pasture scale to explain variation in the data. Linear and quadratic forms of continuous grazing measures were modelled within wetland and pasture model suites. The proportion of perennial cover relative to annual cropland may have a strong effect on the attractiveness of landscapes to birds (Fairbairn and Dinsmore 2001b, Naugle et al. 1999). The effect that total perennial cover, as well as its primary components (grassland and woodland) had on BSR was evaluated at 4 buffer scales (see GIS modelling above). A latitudinal gradient within the Parkland, measured as UTM northing (NORTH) was also considered within this suite of models to account for broad regional differences in climate. Landscape models only included single variables to rank their relative importance as selection criteria for wetland birds. High ranking models identified in *a priori* and landscape suites were then

improved in a multi-level exploratory suite by systematically replacing weak predictors with strong ones. I was interested in comparing the predictive strength of alternate measures of grazing intensity at the pasture scale in place of PVOR. Because the data set for PVOR measurements was incomplete (n=171), I directly compared the top two exploratory models, replacing PVOR with PMAXHGT and PASTSCR in the reduced dataset.

4.3 Nest Density

As a proxy to measure the attractiveness of nesting cover across a grazing continuum at wetland sites in the Parkland, I modelled total nest counts within each of 3 nesting guilds (blackbirds, other songbirds, waterbirds) using generalized linear models, a negative binomial distribution, and a log-link function. Individual wetlands (n = 181) were used as discrete units. Because search areas varied between sites, nest counts of each guild were modelled using the natural log of search area (LNSEARCH) as an offset variable. The use of offset variables transforms count estimates into ratios (Venables and Ripley 2002); in this case, the ratio is nest count per ha of searched wetland habitat.

Eleven potentially important covariates describing habitat types were included in *a priori* modelling of nest density at the wetland scale. An additional 5 variables related to cattle grazing were included separately, or in various combinations with habitat variables. Pasture level modelling included 4 habitat variables and 2 estimates of grazing intensity. Thirteen univariate landscape models ranked the predictability of total perennial cover, total woodland cover, and total grassland cover at 1 – 4 km buffers and included a latitudinal gradient to assess differences between northern and southern study sites. A multi-level suite of candidate models were then considered for exploratory analyses

whereby key variables previously identified by *a priori* and landscape modelling were combined in a logical, additive manner to produce models that best explained the variation in my data.

4.4 Nest Survival

Nest survival of wetland birds was estimated using nest daily survival rates (DSR) and was modelled using generalized non-linear models and a logit-link function for binomially distributed data in NLMIXED SAS (SAS Institute Inc. 2001). Nest daily survival rate (DSR) is defined as the probability that a nest will survive for one day (Dinsmore et al. 2002). Survival rates were calculated for the entire length of time that nest contents were vulnerable to predation. For altricial species, laying, incubation and nestling periods were combined. For precocial species (i.e. young leave the nest soon after hatching), this duration included laying and incubation periods. Four assumptions are implicit in DSR models: 1) observed eggs or young were correctly aged, 2) nest fates were correctly determined, 3) investigator activity, i.e. nest searching and visits, did not impact nest fate, and 4) nest fates were independent.

For nests that are successful, the probability of success follows the formula:

$$P(f = 1) = S_k \cdot S_{k+1} \cdot \ldots \cdot S_l$$

Where f = nest fate (0 = failure, 1 = success), S = the likelihood of a nest surviving for one day, k = day the nest was found, and l = last day the nest was determined to be active (i.e. still active when last visited). Assuming a constant rate of daily survival, the above formula can be expressed as:

$$P(f = 1) = S^{(l-k)}$$

For unsuccessful nests, the probability of nest failure is calculated as:

$$P(f = 0) = [S_k \cdot S_{k+1} \cdot \ldots \cdot S_{l-1}] * [1 - S_l \cdot S_{l+1} \cdot \ldots \cdot S_{m-1}]$$

where m = the day the nest was last checked. The first part of the equation ($[S_k \cdot S_{k+1} \cdot \ldots \cdot S_{l-1}]$) represents the period of time when the nest was viable and the second part ($[1 - S_l \cdot S_{l+1} \cdot \ldots \cdot S_{m-1}]$) represents the interval during which the nest failed.

Daily survival rates were modeled as a logistic function of covariates as follows:

$$\text{logit}(S_i) = \log_e [S_i/(1-S_i)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k$$

Estimates of daily survival were calculated as:

$$S_i = [e^{\beta 0 + \beta 1 X1 \ldots \beta k Xk}] / [1 + e^{\beta 0 + \beta 1 X1 \ldots \beta k Xk}]$$

where S_i = probability of the nest surviving from day *i* to *i*+1, and k = the number of parameters contained in the candidate model.

The term "nest survival" is differentiated from "nest daily survival rates", and refers to the probability that a nest will be successful (Dinsmore et al. 2002). Nest survival probabilities (P) spanning interval lengths are calculated as:

$$P = [(e^{\beta 0 + \beta 1 X1 \ldots \beta k Xk}) / (1 + e^{\beta 0 + \beta 1 X1 \ldots \beta k Xk})]^{\text{interval length}}$$

or more simply as:

$$P = (S_i)^{\text{interval length}}$$

In order to understand the effect that habitat has on nest survival, eleven wetland habitat characteristics were contained in *a priori* candidate models. In addition, 4 wetland grazing parameters that included categorical and continuous measures of grazing intensity were analysed in various combinations with habitat variables. Four covariates describing habitat types at the pasture scale were included in each *a priori* pasture suite. Five continuous or categorical measures of grazing intensity at the pasture level were also included. Relatively few interactions were included in DSR models due to limited

information to justify their inclusion. The ability to model DSR with continuous data is still very new (Howerter 2003). Univariate landscape modelling ranked the effect of total perennial cover, grassland cover, and woodland cover at 1 - 4 km buffers, as well as latitude, on DSR. Key variables identified by *a priori* modelling were then combined in a multi-level exploratory suite to form models that best explained variation within the data.

5.0 RESULTS

5.1 General

Approximately 86.5 ha (Fig. 3) of emergent cover was searched over 83 wetlands in 2001 (range = 0.11-1.61 ha, $\bar{x}$ = 0.53 ha) and resulted in location of 114 blackbird nests, 11 other songbird nests, and 50 waterbird nests. In 2002, 193.5 ha of habitat was searched across 99 wetlands (range = 0.09-2.81 ha, $\bar{x}$ = 0.66 ha) yielding locations for 178 blackbird nests, 92 other songbird nests, and 64 waterbird nests.

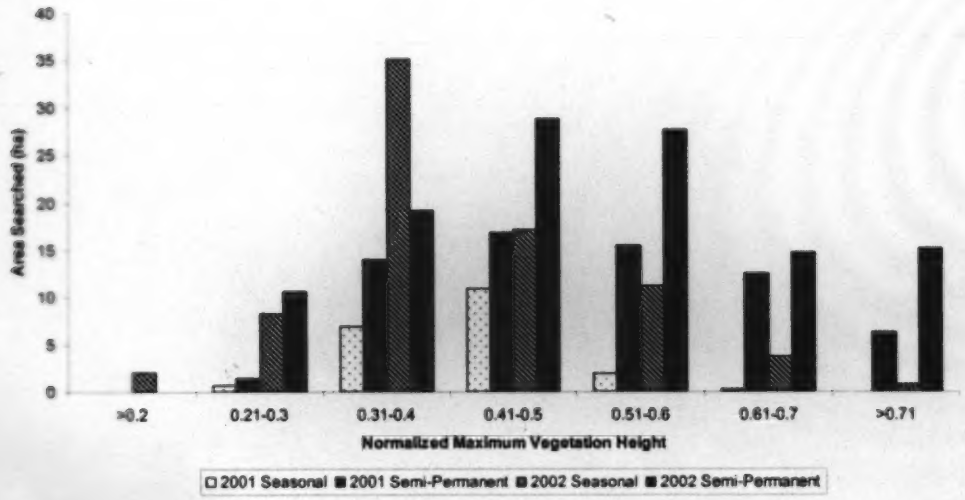

Figure 3: Search areas of seasonal and semi-permanent wetland habitats distributed across normalized maximum vegetation height classes. Data was obtained in 2001 and 2002 in the Aspen Parkland ecoregion of Alberta.

Blackbirds initiated nests from 19-May to 17-July in 2001 and from 18-May to 11-July in 2002, with peak initiation occurring on 19-June and 31-May in 2001 and 2002 respectively. Other songbirds initiated nests from 25-May to 8-July in 2001 and from 15-May to 8-July in 2002 with peak initiation occurring on 13-June and 1-June in 2001 and 2002, respectively. Waterbird nest initiation lasted from 16-May to 11-July in 2001 and from 11-May to 1-July in 2002, with peak initiation occurring on 1-June and 3-June in 2001 and 2002, respectively.

Drought was an important factor for wetland birds in both field seasons. In 2001, only 34.9% of all basins remained wet throughout the breeding season. Continued drought in 2002 resulted in only 15.4% of basins remaining wet throughout the breeding season.

Cattle activity indices ranged from 1.00 to 4.00 in both years, and averaged 2.35 in 2001 and 2.46 in 2002. Normalized maximum vegetation height values ranged from 0.25 to 0.83 ($\bar{x}$ = 0.48) in 2001 and from 0.17 to 0.98 ($\bar{x}$ = 0.45) in 2002. Wetland plant species richness ranged from 7-29 species ($\bar{x}$ = 18.0) in 2001 and from 10-35 species ($\bar{x}$ = 21.3) in 2002. Bare patches within emergent plant communities in 2001 ranged from 0 to 66.3% ($\bar{x}$ = 21.6%) of the total area in 2001 and from 0 to 45% ($\bar{x}$ = 13.7%) in 2002.

In 2001, average residual cover readings in native pastures surrounding wetlands ranged from 0.2 - 25.0 cm ($\bar{x}$ = 4.9 cm) and from 0.06 - 15.5 cm ($\bar{x}$ = 4.48 cm) in tame pastures. Likely as a result of the drought in 2001, residual cover readings were much lower (i.e. probably caused by increased grazing pressure combined with poor regrowth

of vegetation) in 2002, ranging from 0 - 7.0 cm ($\bar{x}$ = 1.2 cm) in native pastures and from 0 - 6.9 cm ($\bar{x}$ = 2.8 cm) in tame.

Aspen stands are common in the Parkland. Across both years, the distance from studied wetlands to the nearest aspen stand ranged from 0-196 m and averaged 36.5 m. Woodland area within pastures was similar between years, ranging from 0 – 56% coverage ($\bar{x}$ = 23%) within native pastures, and from 0 - 36% coverage ($\bar{x}$ = 11%) in tame pastures.

5.2 Breeding Species Richness

A total of 59 bird species were observed in or near wetlands in 2001 (see Appendix 2 for complete species list). Of these, 31 species were designated as being probable or confirmed breeders. In 2002, 74 species were observed; 38 of which were confirmed or probable breeders. Total species richness ranged from 1 to 18 species ($\bar{x}$ = 8.83) in wetlands in 2001 and 1-20 ($\bar{x}$ = 9.18) in 2002. Breeding species richness ranged from 0 to 10 ($\bar{x}$ = 2.66) in 2001 and 0 to 12 ($\bar{x}$ = 3.69) in 2002.

The most complex wetland model provided a reasonable fit to the data (χ^2_{174} = 183.2905, P = 0.300) for BSR. Wetland models consistently demonstrated a strong positive relationship between BSR and wetland area (Table 3; Appendix 4). Furthermore, higher BSR estimates in semi-permanent ponds than seasonal ponds and in the 2002 field season (in relation to 2001) prevailed throughout all models. Within the best wetland model, MAXHGT weakly predicted positive trends with BSR, as 95% confidence intervals for this variable overlapped 0.

Breeding species richness was affected marginally by pasture level effects, as evidenced by the ranking of best models in relation to the null (Table 3).

Table 3: Ranking of candidate models predicting breeding species richness of birds occupying wetland habitats under different grazing regimes in the Aspen Parkland during 2001 and 2002.

Model	K^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Wetland *a priori*[e]				
$BSR_{(1.1906)+(0.2855)LNWAREA+(-0.4073)YEAR1+(-0.2795)PCLASS3+(0.5569)MAXHGT}$	6	-256.29	0.0	0.3098
$BSR_{(1.4678)+(0.2919)LNWAREA+(-0.3992)YEAR1+(-0.3264)PCLASS3}$	5	-254.93	1.4	0.1569
$BSR_{(1.1664)+(0.2665)LNWAREA+(-0.4097)YEAR1+(-0.2719)PCLASS3+(0.5583)MAXHGT+(0.0762)UWTR}$	7	-254.39	1.9	0.1198
$BSR_{(1.5578)+(0.2908)LNWAREA+(-0.4005)YEAR1+(-0.3190)PCLASS3+(-0.0398)CAI}$	6	-253.66	2.6	0.0831
$BSR_{(1.1976)+(0.3451)LNWAREA(NULL)}$[g]	3	-235.98	20.3	<0.0001
Pasture *a priori*[e]				
$BSR_{(1.0983)+(0.1987)PVOR}$	3	-207.72	0.0	0.1240
$BSR_{(1.3070)+(-0.2709)PINTENSEM+(-0.1639)PINTENSEH}$	4	-207.63	0.1	0.1189
$BSR_{(1.1701)NULL}$[g]	2	-206.91	0.8	0.0830
$BSR_{(1.2779)+(0.0890)GRTYPEN+(-0.2721)PINTENSEM+(-0.1698)PINTENSEH}$	5	-206.00	1.7	0.0526
$BSR_{(1.0847)+(0.2752)PVOR+(-0.0460)PVOR^2}$	4	-205.75	2.0	0.0463
$BSR_{(1.3335)+(-0.0637)GRTYPEN+(-0.4172)PINTENSEM+(-0.2148)PINTENSEH+(0.3294)GRTYPEN*PINTENSEM+(0.1120)GRTYPEN*PINTENSEH}$	7	-203.46	4.3	0.0147
Landscape Effects[e]				
$BSR_{(-12.1833)+(0.2281)NORTH}$	3	-209.65	0.0	0.2550
$BSR_{(0.9578)+(0.5682)GL1}$	3	-209.60	0.1	0.2484
$BSR_{(0.9765)+(0.5998)GL2}$	3	-207.26	2.4	0.0770
$BSR_{(1.1701)NULL}$[g]	2	-206.91	2.7	0.0648
$BSR_{(1.2521)+(-0.3570)WO1}$	3	-206.53	3.1	0.0534
$BSR_{(1.4095)+(-0.3361)PC2}$	3	-205.83	3.8	0.0377
Multi-Level[e]				
$BSR_{(1.2246)+(0.2773)LNWAREA+(-0.4828)YEAR1+(-0.3557)PCLASS3+(0.3827)PVOR+(0.3968)GL1}$	7	-266.37	0.0	0.1340
$BSR_{(1.4172)+(0.2905)LNWAREA+(-0.5228)YEAR1+(-0.3929)PCLASS3+(0.5689)PVOR+(0.2157)CP}$	7	-266.19	0.2	0.1222
$BSR_{(1.1701)NULL}$[g]	2	-206.91	59.5	<0.0001
Substituted Variables[f]				
$BSR_{(1.2206)+(0.2741)LNWAREA+(-0.4701)YEAR1+(-0.3695)PCLASS3+(0.3196)PVOR+(0.4364)GL1}$	7	-234.22	0.0	
$BSR_{(1.2317)+(0.2666)LNWAREA+(-0.4210)YEAR1+(-0.3930)PCLASS3+(0.0202)PMAXHGT+(0.4700)GL1}$	7	-229.36	4.9	
$BSR_{(1.2559)+(0.2734)LNWAREA+(-0.4139)YEAR1+(-0.3931)PCLASS3+(0.0007)PSCR+(0.4646)GL1}$	7	-228.90	5.3	

[a] Number of model parameters
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 180 wetlands
[f] Sample size = 171 wetlands
[g] Null model describes base (no effects) model for comparative purposes

There appeared to be a trend toward increased BSR in northern wetlands as evidenced by univariate landscape models (Table 3). The proportion of grassland area within 1 km buffers also positively affected BSR.

The best multi-level model ($BSR_{LNWAREA+YEAR+PCLASS+PVOR+GL1}$; $\Delta AIC_c = 0$, $\omega_i = 0.1340$) included a positive effect of wetland area, and higher BSR estimates in 2002 and in semi-permanent ponds (Table 4). Although wetland grazing variables were not

Table 4: Beta estimates for best approximating model ($BSR_{LNWAREA+YEAR+PCLASS+PVOR+GL1}$; $\Delta AIC_c=0$, $\omega_i = 0.1340$) describing breeding species richness of wetland birds in response to year, habitat, and grazing variables measured in the Aspen Parkland ecoregion in 2001 and 2002.

Parameter	β-Estimate	SE	95% Confidence		ωθ[a]
			Lower	Upper	
INTERCEPT	1.2246	0.1088	1.0114	1.4379	
LNWAREA	0.2773	0.0569	0.1658	0.3883	0.53
$YEAR_{2001}$	-0.4828	0.0934	-0.6659	-0.2997	0.54
$YEAR_{2002}$	0	0	0	0	
$PCLASS_{seasonal}$	-0.3557	0.0975	-0.5468	-0.1645	0.54
$PCLASS_{SEMI-PERMANENT}$	0	0	0	0	
PVOR	0.3827	0.1040	0.1789	0.5865	1.00
GL1	0.3968	0.2223	-0.0388	0.8324	0.39

[a] Relativized parameter weighting for candidate models

represented in the top models, residual pasture cover (PVOR) positively affected BSR (Fig. 4). A latitudinal gradient was stronger in univariate landscape models, however the positive effect of grassland area within a 1 km buffer was more important when modeled with wetland and pasture effects. The next best model ($BSR_{LNWAREA+YEAR+PCLASS+PVOR+CP}$; $\Delta AIC_c = 0.2$, $\omega_i = 0.1222$) was similar, however, it indicated a weakly positive relationship between BSR and cattle presence.

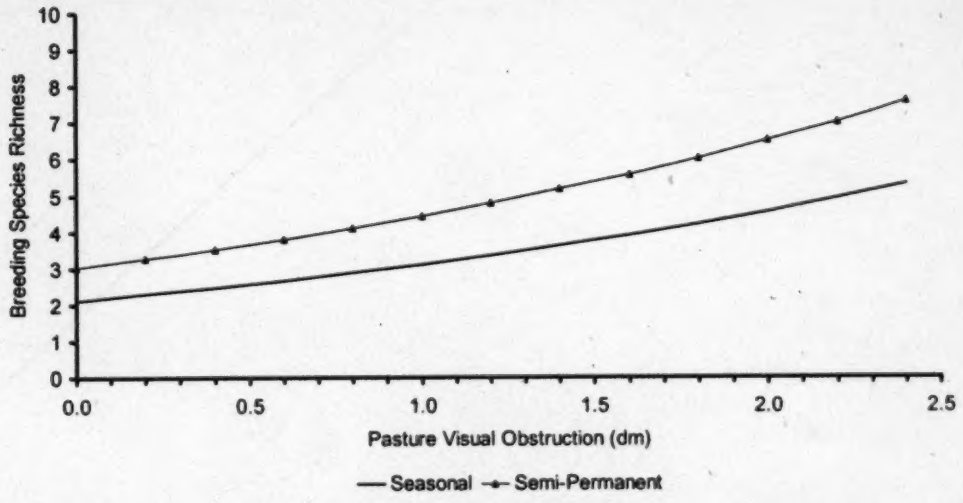

Figure 4: Predicted breeding species richness of birds occupying seasonal and semi-permanent wetlands within pastures in the Aspen Parkland ecoregion of Alberta. Breeding species richness of wetland birds was higher in pastures that had high visual obstruction readings. Other parameters included in the model (GL1, LNWAREA) were held constant at average values. Breeding species richness approximations were averaged across years.

Substituting PMAXHGT or PASTSCR for PVOR in the top ranked multi-level model ($BSR_{LNWAREA+YEAR+PCLASS+PVOR+GL1}$) produced much weaker models (Table 3).

5.3 Blackbird Nest Density

A priori modelling of blackbird nest density (BBND) demonstrated strong ties to habitat and grazing covariates at the wetland scale (Table 5; Appendix 5). The most complex wetland model provided a reasonable fit to the data ($\chi^2_{175} = 185.9131$, P = 0.2719) (Table 5).

Blackbird nest densities were consistently higher in semi-permanent ponds than in seasonal ponds (Table 5) and increased proportionately to MAXHGT. Nest density decreased in relation to wetland size. The best wetland model included a quadratic relationship

Table 5: Ranking of candidate models predicting nest density of blackbirds occupying wetland habitats in relation to cattle grazing intensity in the Aspen Parkland of Alberta between 2001 and 2002.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$BBND_{(-4.0690)+(-1.2911)PCLASS3+(3.8155)MAXHGT+(2.4673)CAI+(-0.4387)CAI^2+(-0.3435)WAREA}$	7	-192.04	0.00	0.6195
$BBND_{(-2.1772)+(-1.3115)PCLASS3+(3.6468)MAXHGT+(0.5188)CAI+(-0.3852)WAREA}$	6	-190.53	1.51	0.2908
$BBND_{(-2.9427)+(-1.1705)PCLASS3+(3.9719)MAXHGT+(0.5874)CAI}$	5	-187.90	4.14	0.0782
$BBND_{(0.2791)NULL}$[g]	2	-164.84	27.20	<0.0001
Pasture *a priori*[e]				
$BBND_{(0.6629)+(-2.7205)WDDENSE}$	3	-166.76	0.00	0.2455
$BBND_{(0.8416)+(-0.7245)PVOR+(0.3767)GRTYPEN+(-3.6399)WDDENSE}$	5	-165.86	0.90	0.1568
$BBND_{(0.2791)NULL}$[g]	2	-164.84	1.92	0.0941
$BBND_{(0.5080)+(-0.8939)PVOR+(0.1637)PVOR^2}$	4	-162.77	3.99	0.0334
$BBND_{(0.5037)+(-0.6409)PVOR+(-0.0802)GRTYPEN}$	4	-162.72	4.04	0.0326
$BBND_{(0.6523)+(-0.7527)PINTENSEL+(-0.2787)PINTENSEH+(-0.1468)GRTYPEN}$	5	-161.60	5.16	0.0186
Landscape Effects[e]				
$BBND_{(0.6809)+(-1.9109)WO1}$	3	-166.33	0.00	0.2753
$BBND_{(0.2791)NULL}$[g]	2	-164.84	1.50	0.1303
Multi-Level Effects[e]				
$BBND_{(-3.9308)+(-1.1539)PCLASS3+(2.4014)CAI+(-0.4335)CAI^2+(4.774)MAXHGT+(-0.3354)WAREA+(-1.8602)WO1}$	8	-193.67	0.00	0.2214
$BBND_{(-3.9257)+(-1.0799)PCLASS3+(2.5593)CAI+(-0.4691)CAI^2+(4.3683)MAXHGT+(-0.3258)WAREA+(-1.1630)WDDENSE+(-1.6439)WO1}$	9	-192.29	1.37	0.1114
$BBND_{(0.2791)NULL}$[g]	2	-164.84	28.83	<0.0001
Substituted Variables[f]				
$BBND_{(-1.8246)+(-1.5262)PCLASS3+(1.6532)CAI+(-0.2676)CAI^2+(4.9717)WVOR+(-0.5279)WAREA+(-3.1256)WO1}$	8	-133.37	0.00	
$BBND_{(-2.8428)+(-1.2503)PCLASS3+(-1.8429)+CAI+(-0.3111)CAI^2+(4.0714)MAXHGT+(-0.3779)WAREA+(-3.0759)WO1}$	8	-129.70	3.49	

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 181 wetlands
[f] Sample size = 97 wetlands
[g] Null model describes base (no effects) model for comparative purposes

between BBND and cattle activity indices, which suggested higher nest densities occurred in wetlands that were moderately impacted by cattle.

Blackbird nest density was poorly predicted by pasture scale models, as evidenced by the relatively high ranking of the null model (Table 5, Appendix 5). The best pasture model predicted reduced BBND in pastures occupied by large woodlots. A competing model provided similar estimates for woodland size effects on BBND, however, it also predicted a weak negative relationship with residual pasture cover and reduced BBND in tame stands.

Scale of perennial cover marginally impacted nest densities (Table 5, Appendix 5). Similar to evidence provided by pasture models, blackbirds weakly avoided landscapes (measured at 1 km buffers) that were heavily wooded.

Exploratory modelling yielded interesting trends, as wetland and landscape variables were represented in top ranking models. Pasture scale variables were not selected as strong predictors. The best candidate model identified within this suite ($BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+WO1}$, $\Delta AIC_c = 0$, $\omega_i = 0.2214$) reinforced trends observed in previous models (Table 6). Positive associations were maintained for semi-permanent ponds and MAXHGT (Fig. 5a). Nest density declined with increased wetland area and blackbirds tended to avoid landscapes occupied by large woodlots. Similar to *a priori* modeling, the best multi-level model also predicted higher blackbird nest densities at wetlands that were moderately impacted by cattle activity (Fig. 5b).

Although WVOR estimates were not available for 2001 data, I observed better predictive capabilities of WVOR in smaller datasets when I replaced MAXHGT in the top exploratory models (Table 5).

Table 6: Beta estimates for best approximating model ($BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+WO1}$; $\Delta AIC_c=0$, ω_i = 0.2214) describing blackbird nest density as a function of grazing and habitat characteristics at wetland and landscape scales in the Aspen Parkland ecoregion in 2001 and 2002.

Parameter	β-Estimate	SE	95% Confidence		$\omega\theta^a$
			Lower	Upper	
INTERCEPT	-3.9308	1.4211	-6.7161	-1.1454	
$PCLASS_{seasonal}$	-1.1539	0.3844	-1.9073	-0.4004	0.55
$PCLASS_{semi\text{-}permanent}$	0	0	0	0	
CAI	2.4014	1.0182	0.4057	4.3971	0.63
CAI^2	-0.4335	0.2240	-0.8726	0.0056	0.83
MAXHGT	4.4774	1.3300	1.8706	7.0842	0.55
WAREA	-0.3354	0.1757	-0.6797	0.0089	0.80
WO1	-1.8602	0.9434	-3.7091	-0.0122	1.00

[a] Relativized parameter weighting for candidate models

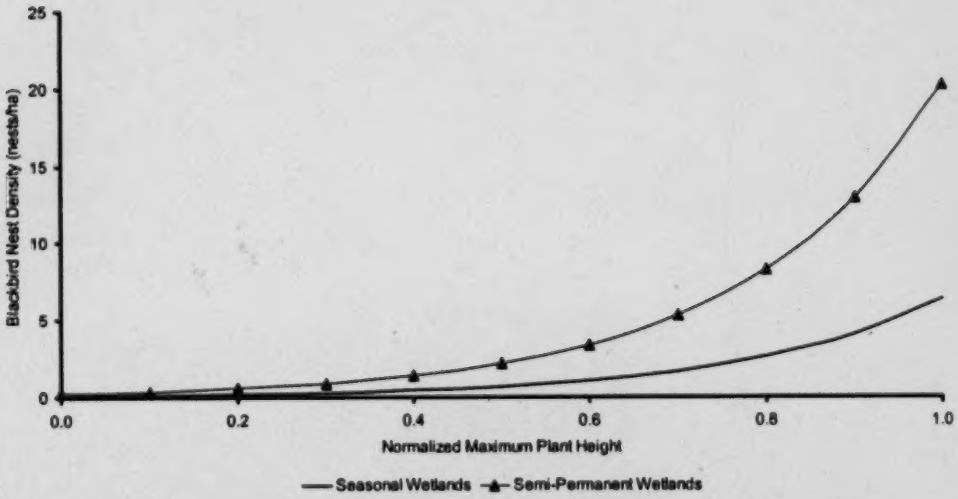

Figure 5a: Predicted nest density estimates for blackbirds nesting in seasonal and semi-permanent wetlands in the Aspen Parkland ecoregion. To facilitate comparison between plant communities of differing maximum plant height, maximum plant height was normalized between 0 and 1. Normalized maximum height measurements are presumed to be diagnostic of cattle grazing within wetland margins. Other parameters included in the model (CAI [quadratic], WAREA, and WO1) were held constant at average values.

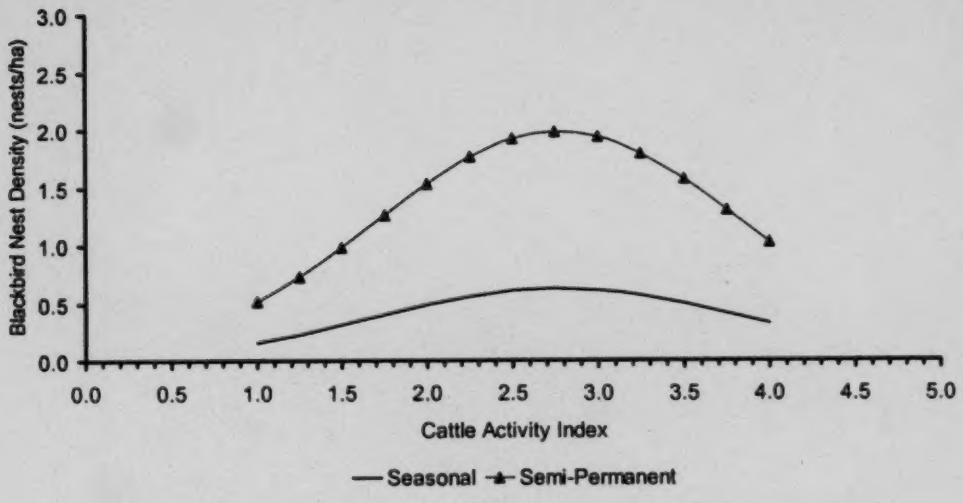

Figure 5b: Predicted nest density estimates for blackbirds nesting in seasonal and semi-permanent wetlands in the Aspen Parkland ecoregion. Cattle activity indices estimate disturbance to soil substrate caused by presence of cattle. Other parameters included in the model (MAXHGT, WAREA, and WO1) were held constant at average values.

5.4 Blackbird Nest Survival

The most parsimonious nest-site model predicting blackbird nest survival (Table 7; Appendix 6) indicated lower DSR in 2002 than in 2001. This model also predicted a weak, positive date effect, and a strong positive effect of increased distance to dry ground. A competing model yielded similar predictions, however it also included a positive relationship between BB-DSR and water depth at the nest site scale and a negative relationship with nest height.

Grazing effects were not included in highly ranked models at the wetland scale (Table 7). Performance of models describing DSR was most improved by increasing colony size. Increased distance to neighbouring seasonal or semi-permanent ponds had a diminishing negative effect on BB-DSR. Nests on wetlands exhibiting cover type 2 characteristics had substantially lower success rates in comparison to cover types 1 and 3,

Table 7: Ranking of candidate models predicting blackbird nest daily survival rates (BB-DSR) in relation to cattle grazing in the Aspen Parkland of Alberta. Only top ranking and selected models from *a priori* and exploratory analyses are included.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Nest Site *a-priori*[e]				
$BB\text{-}DSR_{(1.4664)+(-0.6622)YEAR2+(0.04196)DATE+(0.08142)DISTDRY}$	4	613.0	0.0	0.6686
$BB\text{-}DSR_{(1.5177)+(-0.5861)YEAR2+(0.04218)DATE+(-0.00364)NHGT+(0.008139)NDEPTH+(0.06841)DISTDRY}$	6	615.1	2.1	0.2340
$BB\text{-}DSR_{(0.6021)+(0.04578)DATE+(0.01948)NDEPTH+(0.05625)DISTDRY+(0.001733)NHGT}$	5	617.2	4.2	0.0819
$BB\text{-}DSR_{(2.8009)NULL}$[h]	1	681.8	68.8	<0.0001
Wetland *a priori*[e]				
$BB\text{-}DSR_{(1.5544)+(0.05377)BBNESTS+(1.2596)COVER1+(1.0334)COVER3+(0.9001)WET+(-0.1322)SQRTDISTWET}$	6	610.4	0.0	0.6217
$BB\text{-}DSR_{(2.8082)+(0.05165)BBNESTS+(-1.3305)COVER2+(-0.2707)COVER3+(0.9108)WET+(0.02043)SQRTDISTASP+(-0.1315)SQRTDISTWET}$	7	611.4	1.0	0.3771
$BB\text{-}DSR_{(2.8009)NULL}$[h]	1	681.8	71.4	<0.0001
$BB\text{-}DSR_{(2.8426)+(0.02497)WINTENSEL+(-0.1523)WINTENSEH}$	3	684.9	74.5	<0.0001
Pasture *a priori*[f]				
$BB\text{-}DSR_{(3.4565)+(1.4630)PTREND+(-5.4880)WETDENSE+(-7.9738)PROPWET+(32.1563)WETDENSE*PROPWET+(0.3194)CP}$	6	611.6	0.0	0.5733
$BB\text{-}DSR_{(3.4737)+(1.2751)PTREND+(-4.9999)WETDENSE+(-6.9069)PROPWET+(28.9067)WETDENSE*PROPWET}$	5	612.2	0.6	0.4247
$BB\text{-}DSR_{(2.7801)NULL}$[h]	1	648.7	37.1	<0.0001
$BB\text{-}DSR_{(2.6527)+(0.2297)DIRTYPEN+(0.2328)PINTENSEL+(-0.1057)PINTENSEH}$	4	651.4	39.8	<0.0001
Landscape Univariate Models[g]				
$BB\text{-}DSR_{(2.2399)+(2.9321)WO4}$	2	659.8	0.0	0.5120
$BB\text{-}DSR_{(2.7830)NULL}$[h]	1	676.4	16.6	0.0001
Multi-Level Models[g]				
$BB\text{-}DSR_{(1.4193)+(0.03951)DATE+(0.05881)DISTDRY+(-0.1091)NMAX+(0.7420)COVER1+(1.0084)COVER3+(0.08092)BBNESTS+(0.3844)WET+(-0.08056)SQRTDISTWET+(-0.1679)CAI}$	10	572.2	0.0	0.4560
$BB\text{-}DSR_{(0.9908)+(0.03850)DATE+(0.05632)DISTDRY+(-0.1037)NMAX+(0.7748)COVER1+(1.0215)COVER3+(0.07329)BBNESTS+(0.4836)WET+(-0.08566)SQRTDISTWET}$	9	573.1	0.9	0.2908
$BB\text{-}DSR_{(2.7830)NULL}$[h]	1	676.4	104.2	<0.0001

[a] Number of parameters contained within model, includes intercept
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measure from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 581 nest intervals
[f] Sample size = 550 nest intervals
[g] Sample size = 576 nest intervals
[h] Null model describes base (no effects) model for comparative purposes

as did wetlands that dried during the breeding season compared to ponds that remained wet.

Although nest density was poorly estimated by pasture variables, I found strong effects at the pasture scale on DSR. The best pasture model (Table 7) suggested highest survival rates occurred in lightly grazed pastures in which a high proportion of wetlands remained flooded throughout the breeding season. Lower survival rates for blackbird nests were observed in pastures having high wetland density, however, this trend was reversed when greater proportions of basins remained wet throughout the breeding season. Blackbird nests were also more successful in relation to PTREND, however it is interesting to note that the presence of cattle contributed to higher survival rates. The positive effect of cattle presence was not observed in the next strongest model (Table 7).

Blackbirds avoided nesting in landscapes occupied by large stands of aspen (Table 6), but nest survival improved with increased woody cover at 4 km buffers (Table 7). The strength of individual landscape variables compared to wetland or pasture scale variables is questionable however, as the best multi-level models are comprised only of smaller scale parameters (Table 8).

Exploratory modelling suggested habitat and grazing variables measured at the nest site and wetland scale, were more important than pasture or landscape characteristics (Table 7, Appendix 6). The best multi-level model ($BB\text{-}DSR_{DATE+DISTDRY+NMAX+BBNESTS+COVER+WET+SQRTDISTWET+CAI}$, $\Delta AIC_c = 0$, $\omega_i = 0.4560$) demonstrated the effects of date, nesting habitat, coloniality, and cattle activity on the nest success of blackbirds. Nest survival increased marginally as the breeding season progressed (Table 8). Survival rates of blackbird nests were positively affected by NDISTDRY, but declined in relation to

Table 8: Beta estimates for best approximating model (BB-$DSR_{DATE+DISTDRY+NMAX+COVER+BBNESTS+WET+SQRTDISTWET+CAI}$; ΔAIC_c=0, ω_i = 0.4560) describing blackbird nest survival as a function of nest site characteristics, physical components of wetland habitats and cattle grazing in the Aspen Parkland ecoregion.

Parameter	β-Estimate	SE	95% Confidence		$\omega\theta^a$
			Lower	Upper	
INTERCEPT	1.4193	0.5782	0.2836	2.5549	
DATE	0.0395	0.0076	0.0246	0.0544	0.65
NDISTDRY	0.0558	0.0242	0.0083	0.1034	0.65
NMAX	-0.1091	0.0354	-0.1787	-0.0396	0.65
BBNESTS	0.0809	0.0181	0.0453	0.1165	0.65
COVER TYPE 1	0.7420	0.5177	-0.2748	1.7589	
COVER TYPE 2	0	0	0	0	1.00
COVER TYPE 3	1.0084	0.2576	0.5023	1.5144	
WET	0.3844	0.2169	-0.0416	0.8103	0.64
SQRTDISTWET	-0.0806	0.0285	-0.1365	-0.0246	0.65
CAI	-0.1679	0.0990	0.3624	0.0266	0.56

[a] Relativized parameter weighting for candidate models

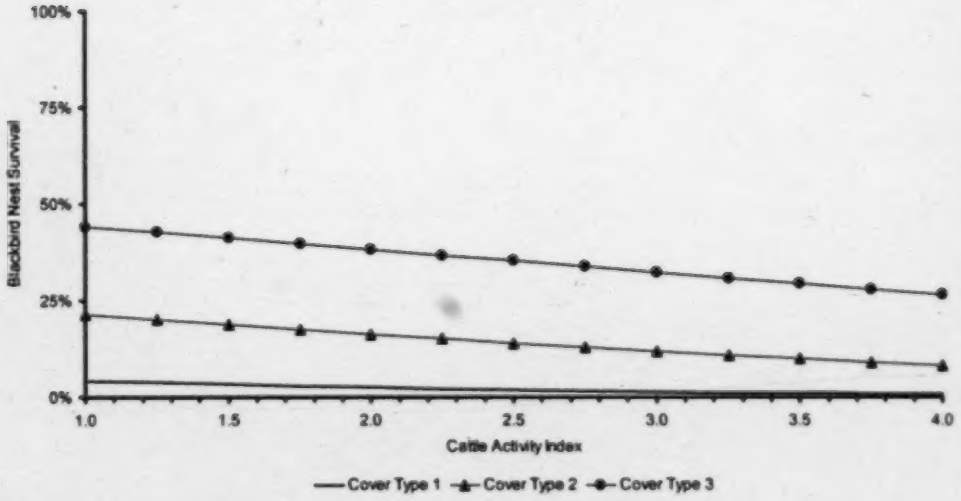

Figure 6: Predicted nest survival of blackbirds nesting in wetlands in the Aspen Parkland ecoregion. Cattle activity indices estimate disturbance to soil substrate caused by cattle. Blackbird nest success declined as activity indices increased. Other parameters included in the model (DATE, DISTDRY, NMAX, BBNESTS, WET, and SQRTDISTWET) were held constant at average values.

increased estimates of NMAXHGT. Increased BBNESTS within a colony increased success for individuals (Table 8). Similar to patterns observed in wetland scale models, nests in wetland cover types 1 and 3 had higher success rates than those in cover type 2. Wetlands that remained flooded through July were more likely to host successful nests than wetlands that dried prior to the end of the breeding season. Blackbird nests had low survival rates in isolated wetlands (i.e. increased values of SQRTDISTWET). Nest survival declined in a linear fashion as activity indices increased (Fig. 6).

5.5 Other Songbird Nest Density

Because of large variation in the number of nests observed between field seasons (i.e. likely as a result of water availability from runoff), YEAR was an effect common to all wetland and multi-level models. The most complex wetland model provided a reasonable fit to the data ($\chi^2_{175} = 174.2316$, P=0.5021). Wetland models were generally poor in predicting nest density patterns of other songbirds, as evidenced by the strength of the null model in relation to other candidate models (Table 9).

Other songbirds responded differently to variations in grazing intensity, depending on pasture type (Table 9). A strong preference to nest in moderately grazed native pastures was evident in the best model, compared to heavily grazed or lightly grazed sites. Within tame pastures, other songbirds nested in equally high densities in moderate and heavily grazed pastures, relative to idled or lightly grazed sites.

Variations in landcover surrounding study sites did not appear to impact nest density of other songbirds. The only models to out perform the null or no effects model (Table 9) included woodland area measured at 3 and 4 km buffers. Both of these models predicted weakly increasing nest densities in landscapes with high woodland densities.

Table 9: Ranking of candidate models from *a priori* and exploratory analyses predicting nest density of other songbirds occupying wetland habitats in relation to cattle grazing intensity in the Aspen Parkland of Alberta in 2001 and 2002.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$OSND_{(-0.7966)+(-1.4718)YEAR1(NULL)}$[f]	3	215.99	0.0	0.2372
$OSND_{(-0.6590)+(-1.4751)YEAR1+(-0.0597)CAI}$	4	217.80	1.8	0.0964
$OSND_{(-0.7360)+(-1.4871)YEAR1+(-0.1062)PCLASS3}$	4	217.91	1.9	0.0912
$OSND_{(-0.5074)+(-1.4044)YEAR1+(-0.2378)CAI+(0.0400)CAI^2}$	5	219.86	3.9	0.0344
$OSND_{(-0.6059)+(-1.4672)YEAR1+(-0.9509)MAXHGT+(1.0481)MAXHGT^2}$	5	220.08	4.1	0.0308
Pasture *a priori*[f]				
$OSND_{(-0.9572)+(-1.8428)PINTENSEM+(0.2778)PINTENSEH+(0.2009)GRTYPEN+(1.5259)PINTENSEM*GRTYPEN+(-0.7997)PINTENSEH*GRTYPEN}$	7	227.50	0.0	0.8851
$OSND_{(-1.7496)+(0.8130)PINTENSEL+(0.7230)PINTENSEH+(0.1317)GRTYPEN}$	5	234.65	7.2	0.0248
$OSND_{(-1.1097)NULL}$[f]	2	235.82	8.3	0.0139
$OSND_{(-1.1746)+(0.0321)PVOR+(0.1134)GRTYPEN}$	4	239.75	12.2	0.0019
$OSND_{(-0.9728)+(-0.6264)PVOR+(-0.1922)GRTYPEN+(0.9526)PVOR*GRTYPE}$	5	239.84	12.3	0.0019
Landscape Effects[e]				
$OSND_{(-1.3834)+(1.3168)WO4}$	3	234.83	0.0	0.1625
$OSND_{(-1.3625)+(1.1728)WO3}$	3	235.08	0.2	0.1435
$OSND_{(-1.1097)NULL}$[f]	2	235.82	1.0	0.0992
$OSND_{(-18.4267)+(0.2958)NORTH}$	3	236.61	1.8	0.0666
$OSND_{(-1.6644)+(0.7081)PC1}$	3	236.90	2.1	0.0576
Multi-Level[f]				
$OSND_{(-2.8176)+(-1.9134)YEAR1+(2.0624)PINTENSEL+(2.1078)PINTENSEH+(1.7155)GRTYPEN+(-1.7919)PINTENSEL*GRTYPEN+(-2.3267)PINTENSEH*GRTYPEN+(1.4413)WO4}$	9	202.34	0.0	0.2525
$OSND_{(-2.7263)+(-1.5627)YEAR1+(-0.2934)PCLASS3+(1.9953)PINTENSEL+(2.1120)PINTENSEH+(1.8070)GRTYPEN+(-1.7333)PINTENSEL*GRTYPEN+(-2.4370)PINTENSEH*GRTYPEN+(1.4838)WO4}$	10	203.10	0.8	0.1726
$OSND_{(-0.7966)+(-1.4718)YEAR1(NULL)}$[f]	3	213.93	11.6	0.0008

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 181 wetlands
[f] Null model describes base (no effects) model for comparative purposes

The best multi-level model ($OSND_{YEAR+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$, $\Delta AIC_c = 0$, ω_i =0.2525, Table 10) reinforced the attraction of other songbirds to wetlands within moderate and heavily grazed tame pastures and moderately grazed native pastures (Fig. 7). OSND increased in concert with increasing woodland cover at the 4 km scale surrounding both pasture types.

Table 10: Beta estimates for best approximating model ($OSND_{YEAR+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$; ΔAIC_c=0,ω_i = 0.2525) describing other songbird nest density as a function of grazing intensity, pasture type and woodland density in the Aspen Parkland.

Parameter	β-Estimate	SE	95% Confidence		ωθ[a]
			Lower	Upper	
INTERCEPT	-2.8176	0.5998	-3.9932	-1.6419	
YEAR1	-1.5154	0.3515	-2.2044	-0.8265	0.92
YEAR2	0	0	0	0	
PINTENSE L	2.0624	0.6223	0.8428	3.2820	
PINTENSE M	0	0	0	0	0.80
PINTENSE H	2.1078	0.6169	0.8987	3.3169	
GRTYPEN	1.7155	0.6454	0.4505	2.9805	0.80
GRTYPET	0	0	0	0	
PINTENSEL*GRTYPEN	-1.7919	0.7376	-3.2376	0.3461	
PINTENSEL*GRTYPET	0	0	0	0	
PINTENSEM*GRTYPEN	0	0	0	0	0.80
PINTENSEM*GRTYPET	0	0	0	0	
PINTENSEH*GRTYPEN	-2.3267	0.7305	-3.7585	-0.8948	
PINTENSEH*GRTYPET	0	0	0	0	
WO4	1.4413	0.6971	0.0749	2.8076	1.00

[a] Relativized parameter weighting for candidate models

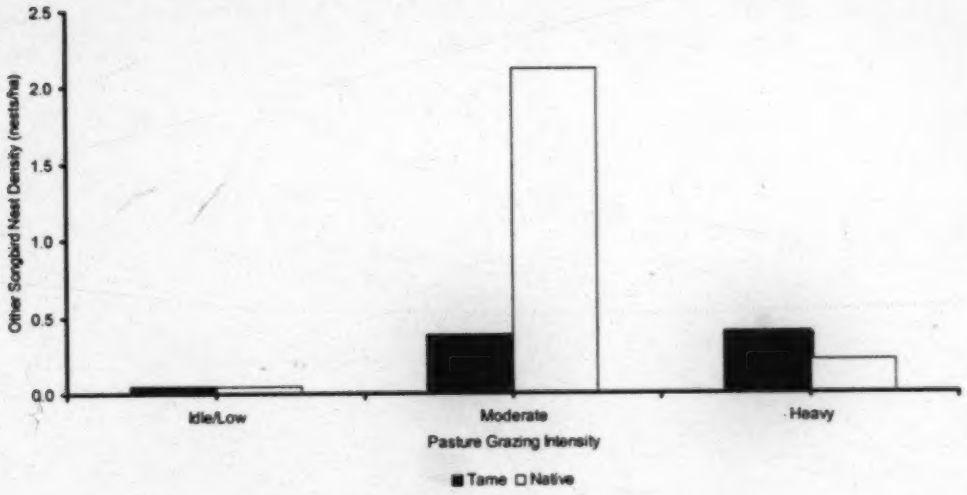

Figure 7: Nest density estimates for other songbirds nesting in wetlands in Aspen Parkland pastures. Pasture grazing intensity is a subjective categorization based on visual estimates of pasture condition and residual cover height and density. Average values of WO4 were used to create this plot. Predictions of other songbird nest density were averaged over both years.

5.6 Other Songbird Nest Survival

The most parsimonious nest site model predicting DSR for other songbirds included reduced nest survival estimates for 2002 in relation to 2001, and a weak, but positive date effect (Table 11).

Habitat types, rather than grazing effects appeared to be more important in predicting nest success of other songbirds at the wetland scale. The best wetland model (Table 11) indicated nest survival rates were lower in semi-permanent ponds than seasonal ponds and were higher in cover type 2 ponds in relation to cover types 1 or 3.

No landscape models were found to enhance estimates of nest survival of other songbirds, in comparison to the null model (Table 11).

Table 11: Ranking of models predicting other songbird nest daily survival rates (OS-DSR). Only top ranking and selected models from *a priori* and exploratory analyses are included.

Model	K[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Nest Site *a priori*[e]				
$OS\text{-}DSR_{(20.1584)+(-17.3219)YEAR2+(0.02323)DATE}$	3	178.5	0.0	0.8023
$OS\text{-}DSR_{(3.1822)+(0.1232)HMAX}$	2	183.4	4.9	0.0692
$OS\text{-}DSR_{(3.7750)NULL}$[f]	1	183.5	5.0	0.0659
$OS\text{-}DSR_{(3.6571)+(0.7734)CY}$	2	183.6	5.1	0.0626
Wetland *a priori*[e]				
$OS\text{-}DSR_{(20.8391)+(-0.1701)PCLASS4+(-17.0528)COVER1+(-17.1812)COVER3}$	4	176.9	0.0	0.6940
$OS\text{-}DSR_{(4.5383)+(-1.9495)MAXHGT+(-3.0617)WTREND+(8.9775)MAXHGT*WTREND}$	4	180.0	3.1	0.1473
$OS\text{-}DSR_{(3.7750)NULL}$[f]	1	183.5	6.6	0.0256
$OS\text{-}DSR_{(3.3800)+(2.9544)MAXHGT+(-3.9393)MAXHGT^2}$	3	185.4	8.5	0.0099
$OS\text{-}DSR_{(3.8183)+(-0.1603)WINTENSEL+(0.07121)WINTENSEH}$	3	187.3	10.4	0.0038
Pasture *a priori*[e]				
$OS\text{-}DSR_{(3.0305)+(0.8227)PINTENSEL+(1.0568)PINTENSEH}$	3	183.1	0.0	0.2185
$OS\text{-}DSR_{(3.7750)NULL}$[f]	1	183.5	0.4	0.1789
$OS\text{-}DSR_{(4.1043)+(-4.6325)PVOR+(5.7804)PVOR^2}$	3	183.8	0.7	0.1540
$OS\text{-}DSR_{(2.8634)+(0.2149)PCTYPEN+(0.8827)PINTENSEL+(1.1533)PINTENSEH}$	4	184.9	1.8	0.0889
Landscape Univariate[e]				
$OS\text{-}DSR_{(3.7750)NULL}$[f]	1	183.5	0.0	0.1225
$OS\text{-}DSR_{(3.2059)+(1.4885)GL1}$	2	183.6	0.1	0.1165
$OS\text{-}DSR_{(-28.6301)+(0.5331)NORTH}$	2	183.9	0.4	0.1003
$OS\text{-}DSR_{(2.7331)+(1.3139)PC1}$	2	184.2	0.7	0.0863
$OS\text{-}DSR_{(4.0245)+(-0.9595)WO1}$	2	184.4	0.9	0.0781
Multi-Level[e]				
$OS\text{-}DSR_{(17.2437)+(-17.1870)YEAR2+(0.02349)DATE+(-4.4874)PCTOPEN+(0.7810)CAI+(2.4208)WTREND+(2.4187)PINTENSEL+(1.1354)PINTENSEH}$	8	167.7	0.0	0.3666
$OS\text{-}DSR_{(-0.1932)+(0.02415)DATE+(-4.3018)PCTOPEN+(0.8562)CAI+(2.6417)WTREND+(2.5277)PINTENSEL+(1.1862)PINTENSEH}$	7	168.9	1.2	0.2012
$OS\text{-}DSR_{(3.7750)NULL}$[f]	1	183.5	15.8	0.0001

[a] Number of parameters contained within model, includes intercept
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measure from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 271 nest intervals
[f] Null model describes base (no effects) model for comparative purposes

The most parsimonious model derived from exploratory analyses included variables from nest site, wetland and pasture scale models (Table 11). Survival rates of other songbirds were lower in 2002, however nests that were initiated later in each season were more successful (Table 12). Survival rates were low for other songbird nests as the proportion of open water in the wetland increased. Nest survival was higher in wetlands that exhibited greater cattle activity indices (Fig. 8a), however survival also increased with net gains to plant height and density in emergent communities between the start and end of the breeding season (Fig. 8b). Similar to pasture level predictions, other songbird nests in moderately grazed pastures had lower survival rates than those in idle/lightly grazed or heavily grazed pastures.

Table 12: Beta estimates for best approximating model (OS-$DSR_{YEAR+DATE+PCTOPEN+CAI+WTREND+PINTENSE}$; ΔAIC_c=0, ω_i = 0.3666) describing other songbird nest survival as a function of field season, date, physical properties of wetland habitat, grazing indices and grazing measures at the pasture scale in the Aspen Parkland.

Parameter	β-Estimate	SE	95% Confidence		$\omega\theta^a$
			Lower	Upper	
INTERCEPT	17.2437	0.6692	15.9262	18.5612	
YEAR1	0	0	0	0	0.68
YEAR2	-17.1870	0.6692	-18.5044	-15.8695	
DATE	0.0235	0.0155	-0.0070	0.0540	0.53
PCTOPEN	-4.4874	1.5967	-7.6309	-1.3440	0.46
CAI	0.7810	0.3938	0.00564	1.5563	0.08
WTREND	2.4208	0.8268	0.7931	4.0485	0.46
PINTENSE L	2.4187	0.7716	0.8996	3.9378	
PINTENSE M	0	0	0	0	1.00
PINTENSE H	1.1354	0.6177	-0.0807	2.3515	

[a] Relativized parameter weighting for candidate models

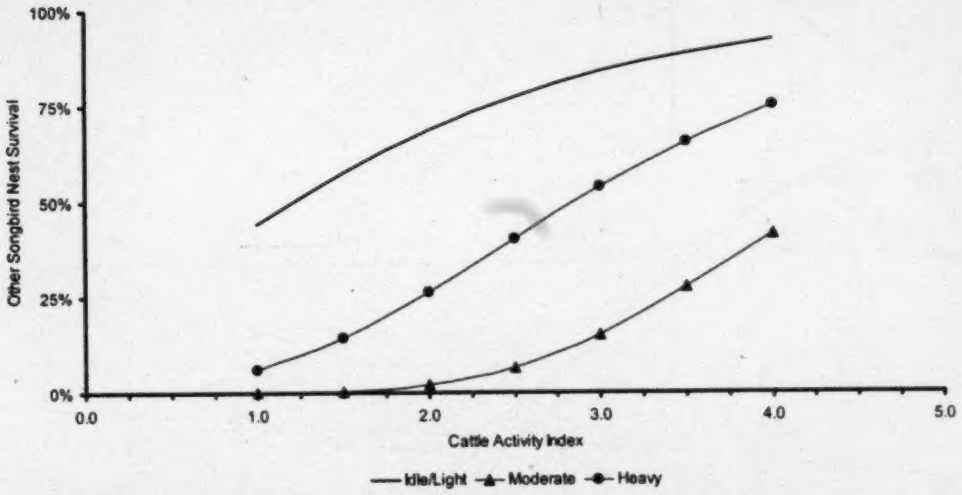

Figure 8a: Nest survival estimates for other songbirds nesting in wetlands within idled/lightly grazed, moderately grazed and heavily grazed pastures in the Aspen Parkland in 2002. Survival rates increased in relation to cattle activity indices. Other parameters included in the model (DATE, PCTOPEN, and WTREND) were set to average values to create this plot.

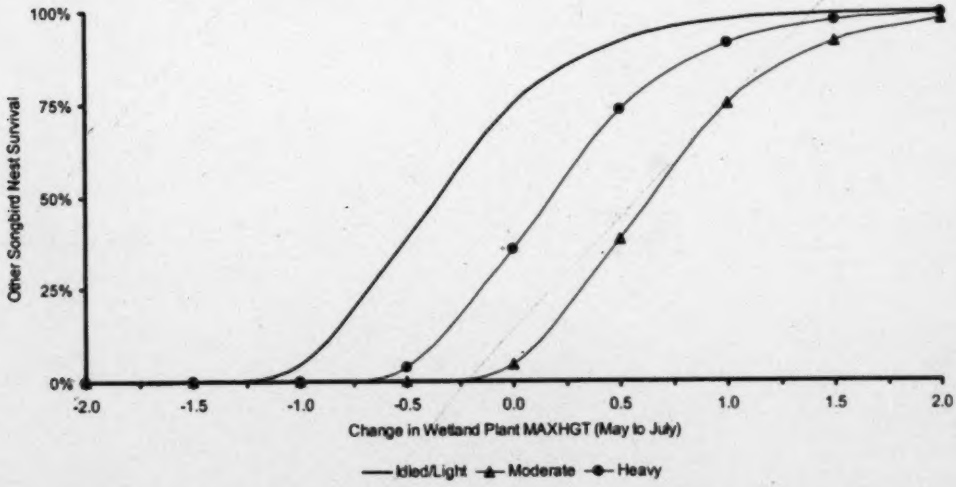

Figure 8b: Nest survival estimates for other songbirds nesting in wetlands within idled/lightly grazed, moderately grazed and heavily grazed pastures in the Aspen Parkland in relation to changes in maximum plant height of wetland vegetation between May and July 2002. Survival rates increased in relation to growth of wetland plants. Other parameters included in the model (DATE, PCTOPEN, and CAI) were set to average values to create this plot.

5.7 Waterbird Nest Density

The most complex candidate wetland model predicting waterbird nest density (Table 13) provided a reasonable fit to the data ($\chi^2_{175} = 172.7$, $P = 0.54$). Top ranking wetland models indicated preference by waterbirds for semi-permanent ponds relative to seasonal wetlands. The best wetland model also indicated greater densities occurred in ponds that were moderately impacted by cattle activity (Table 13).

The best *a priori* pasture model indicated greater waterbird nest densities in wetlands located within moderately grazed uplands. Although this trend was similar between grass types, more nests were found in native pastures (67 nests) than in tame communities (47 nests). Waterbirds avoided areas of high woodland density at pasture and landscape scales, preferring to nest in landscapes that had a high proportion of grassland (Table 13, Appendix 8).

Model strength improved by combining variables from wetland, pasture and landscape scales (Table 14). The best model ($WBND_{PCLASS+CAI+CAI^2+GRTYPE+WDDENSE}$, $\Delta AIC_c = 0.0$, $\omega_i = 0.2739$) supported a preference by waterbirds for semi-permanent ponds that were moderately impacted by cattle activity and native pastures (Table 14, Fig. 9). Selection against areas of high woodland density remained. However, the effect was strongest at the pasture scale, rather than at the landscape scale.

5.8 Waterbird Nest Survival

YEAR and DATE were more important predictors of daily survival rates than were measures of habitat immediately surrounding nest sites of waterbirds. Waterbird nests were more successful in the first year of the study. However, daily survival rates in each year improved with calendar date (Table 15).

Table 13: Ranking of candidate models from *a priori* and exploratory analyses predicting nest density of waterbirds in response to cattle grazing intensity in wetlands of the Aspen Parkland of Alberta between 2001 and 2002.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$WBND_{(-2.8455)+(-0.9675)PCLASS+(2.0351)CAI+(-0.3856)CAI^2}$	5	192.28	0.0	0.2049
$WBND_{(-0.5047)+(-0.9784)PCLASS3}$	3	193.47	1.2	0.1126
$WBND_{(-0.6234)+(-1.2134)PCLASS3+(0.2132)COVER1+(1.0199)COVER2}$	5	193.50	1.2	0.1111
$WBND_{(-2.0233)+(-0.8742)PCLASS3+(1.0854)MAXHGT+(0.3941)CAI}$	5	193.84	1.6	0.0938
$WBND_{(-0.7536)NULL}$[f]	2	197.47	5.2	0.0152
Pasture *a priori*[e]				
$WBND_{(-0.1786)+(-0.7655)PINTENSEL+(-0.5052)PINTENSEH+(0.7883)GRTYPEN+(-4.4301)WDDENSE}$	6	192.12	0.0	0.4331
$WBND_{(-0.4926)+(-0.2170)PVOR+(0.9087)GRTYPEN+(-4.7860)WDDENSE}$	5	193.14	1.0	0.2608
$WBND_{(-0.3111)+(-3.2312)WDDENSE}$	3	194.42	2.3	0.1371
$WBND_{(-0.7536)NULL}$[f]	2	197.47	5.3	0.0299
$WBND_{(-0.7722)+(0.3337)PVOR+(-0.3600)PVOR^2}$	4	201.31	9.2	0.0044
Landscape Effects[e]				
$WBND_{(-0.2872)+(-2.2765)WO1}$	3	194.39	0.0	0.3026
$WBND_{(-1.5398)+(1.9360)GL1}$	3	194.90	0.5	0.2343
$WBND_{(-0.7536)NULL}$[f]	2	197.47	3.1	0.0647
Multi-Level[e]				
$WBND_{(-2.9646)+(-0.8219)PCLASS3+(2.4899)CAI+(-0.5045)CAI^2+(0.7880)GRTYPEN+(-4.4870)WDDENSE}$	7	187.13	0.0	0.2739
$WBND_{(-0.4427)+(-0.8532)PCLASS3+(-4.0652)WDDENSE+(0.8800)GRTYPEN}$	5	188.88	1.8	0.1138
$WBND_{(-2.8280)+(-0.8672)PCLASS3+(2.4498)CAI+(-0.4714)CAI^2+(-0.1093)PINTENSEL+(-0.6053)PINTENSEH+(0.7474)GRTYPEN+(-4.4041)WDDENSE}$	9	189.18	2.1	0.0982
$WBND_{(-0.7536)NULL}$[f]	2	197.47	10.3	0.0016

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 181 wetlands
[f] Null model describes base (no effects) model for comparative purposes

Table 14: Beta estimates for best approximating model ($WBND_{PCLASS+CAI+CAI^2+GRTYPE+WDDENSE}$; $\Delta AIC_c=0$, $\omega_i = 0.2739$) describing waterbird nest density as a function of wetland permanence, activity indices, grass type and woodland density in pastures of the Aspen Parkland.

Parameter	β-Estimate	SE	95% Confidence		$\omega\theta^a$
			Lower	Upper	
INTERCEPT	-2.9646	1.0737	-5.0690	-0.8602	
$PCLASS_{SEASONAL}$	-0.8219	0.3865	-1.5794	-0.0644	0.32
$PCLASS_{SEMI-PERMANENT}$	0	0	0	0	
CAI	2.4899	1.1344	0.2666	4.7133	0.73
CAI^2	-0.5045	0.2524	-0.9992	-0.0098	1.00
$GRTYPE_{NATIVE}$	0.7880	0.3698	0.0632	1.5129	0.81
$GRTYPE_{TAME}$	0	0	0	0	
WDDENSE	-4.4870	1.5348	-7.4951	-1.4789	0.32

[a] Relativized parameter weighting for candidate models

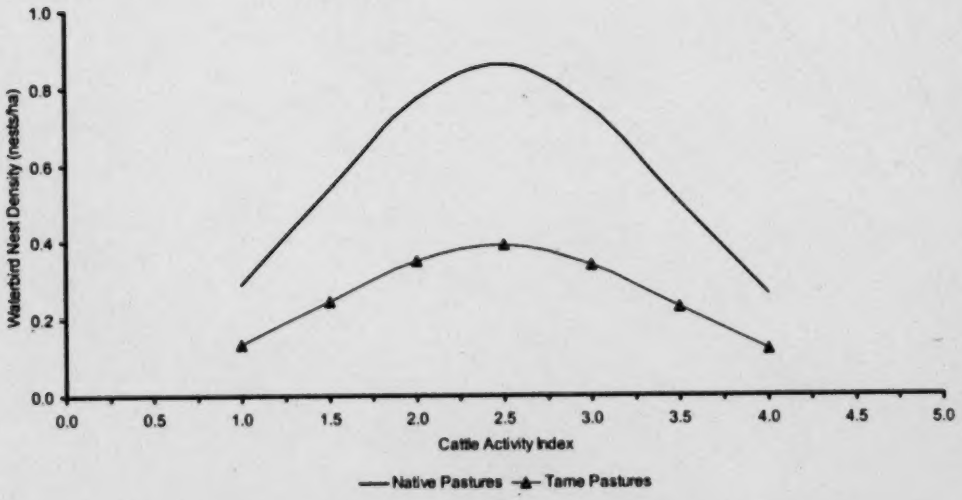

Figure 9: Nest density estimates for waterbirds nesting in seasonal and semi-permanent wetlands within native and tame pastures in the Aspen Parkland ecoregion in 2001 and 2002. Nest density peaked at sites that were moderately impacted by cattle activity. The other parameter included in this model (WDDENSE) was set to an average value and estimations of nest density were averaged over pond classes to create this plot.

Grazing measures were less important to nest success rates than habitat characteristics in wetland-scale models. Semi-permanent ponds produced more successful nests than did seasonal ponds. Within the best wetland model, nest survival was greatest in ponds with cover type 1, however it is interesting to note that the next best model indicated increased proportions of open water to be important to nest survival. Nests located in larger wetlands had higher survival rates (Table 15).

Grazing effects (e.g. PVOR, PINTENSE) on nest success were evident in pasture models (Table 15). Nest survival was highest in wetlands surrounded by uplands with intermediate quantities of residual cover.

Waterbird nest survival appeared to decline as the amount of total perennial cover occupying 3 and 4 km buffers around pastures increased (Table 15).

The best combined-effects model indicated differences in nest survival rates that were dependent on nest type (Table 16). Nests located over water were more likely to survive than nests located in dry emergent cover (Fig. 10). Nests located in large ponds with cover types 1 or 3 characteristics had greater nest survival than those in small ponds, or ponds with cover type 2 characteristics. Nest survival also increased in relation to residual cover estimates of upland vegetation.

Whereas pasture scale models predicted an intermediate response to residual cover, the best combined-effects model indicated a linear relationship (Fig. 10).

Table 15. Ranking of models predicting waterbird nest daily survival rates (WB-DSR) in the Aspen Parkland of Alberta in 2001 and 2002. Only top ranking and selected models from *a priori* and exploratory analyses are included.

Model	K[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Nest Site *a priori*[e]				
$WB\text{-}DSR_{(2.0146)+(0.7707)YEAR1+(0.01077)DATE}$	3	279.8	0.0	0.8504
$WB\text{-}DSR_{(3.0590)+(-0.6059)NTYPEGR}$	2	283.9	4.1	0.1095
$WB\text{-}DSR_{(2.8237)NULL}$[h]	1	287.6	7.8	0.0172
Wetland *a priori*[e]				
$WB\text{-}DSR_{(2.9445)+(0.6765)PCLASS4+(-1.5884)COVER2+(-0.5158)COVER3}$	4	276.8	0.0	0.4770
$WB\text{-}DSR_{(1.7110)+(0.5923)WAREA+(2.0353)PCTOPEN}$	3	277.0	0.2	0.4316
$WB\text{-}DSR_{(2.8237)NULL}$[h]	1	287.6	10.8	0.0022
Pasture *a priori*[f]				
$WB\text{-}DSR_{(2.3263)+(2.1462)PVOR+(-0.8644)PVOR^2}$	3	264.0	0.0	0.6926
$WB\text{-}DSR_{(1.6510)+(1.7464)WETDENSE+(13.9181)PROPWET+(-26.5174)WETDENSE*PROPWET}$	4	267.2	3.2	0.1398
$WB\text{-}DSR_{(2.8278)NULL}$[h]	1	272.9	8.9	0.0081
$WB\text{-}DSR_{(3.0135)+(0.1740)GRTYPEN+(-0.1722)PINTENSEM+(-0.5979)PINTENSEH}$	4	275.1	11.1	0.0027
Landscape Univariate[g]				
$WB\text{-}DSR_{(4.2772)+(-2.2157)PC4}$	2	279.9	0.0	0.3409
$WB\text{-}DSR_{(3.9789)+(-1.7398)PC3}$	2	281.6	1.7	0.1457
$WB\text{-}DSR_{(2.7962)NULL}$[h]	1	283.9	4.0	0.0461
Multi-Level[f]				
$WB\text{-}DSR_{(2.8355)+(-0.6134)NTYPEGR+(-1.2507)COVER2+(-0.3505)COVER3+(0.3802)WAREA+(0.7750)PVOR}$	6	257.1	0.0	0.2174
$WB\text{-}DSR_{(2.7012)+(-1.1706)COVER2+(-0.3251)COVER3^2+(0.3488)WAREA+(1.5156)PVOR+(-0.4589)PVOR^2+(-0.5626)NTYPEGR}$	7	257.8	0.7	0.1532
$WB\text{-}DSR_{(2.8278)NULL}$[h]	1	272.9	15.8	0.0001

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 233 nest intervals
[f] Sample size = 222 nest intervals
[g] Sample size = 229 nest intervals
[h] Null model describes base (no effects) model for comparative purposes

Table 16: Beta estimates for best approximating model ($WB\text{-}DSR_{NTYPE+COVER+WAREA+PVOR}$; $\Delta AIC_c=0$, ω_i = 0.1943) describing waterbird nest survival as a function of nest type, cover type, wetland area and pasture visual obstruction readings in the Aspen Parkland.

Parameter	β-Estimate	SE	95% Confidence		$\omega\theta^a$
			Lower	Upper	
INTERCEPT	2.8355	0.7139	1.4285	4.2425	
$NTYPE_{GRASSLAND}$	-0.6134	0.2782	-1.1616	-0.0652	0.99
$NTYPE_{OVERWATER}$	0	0	0	0	
COVER TYPE 1	0	0	0	0	
COVER TYPE 2	-1.2507	0.7062	-2.6425	0.1411	1.00
COVER TYPE 3	-0.3505	0.6410	-1.6137	0.9127	
WAREA	0.3802	0.2369	-0.0867	0.8472	0.91
PVOR	0.7750	0.3523	-0.0806	1.4693	0.91

[a] Relativized parameter weighting for candidate models

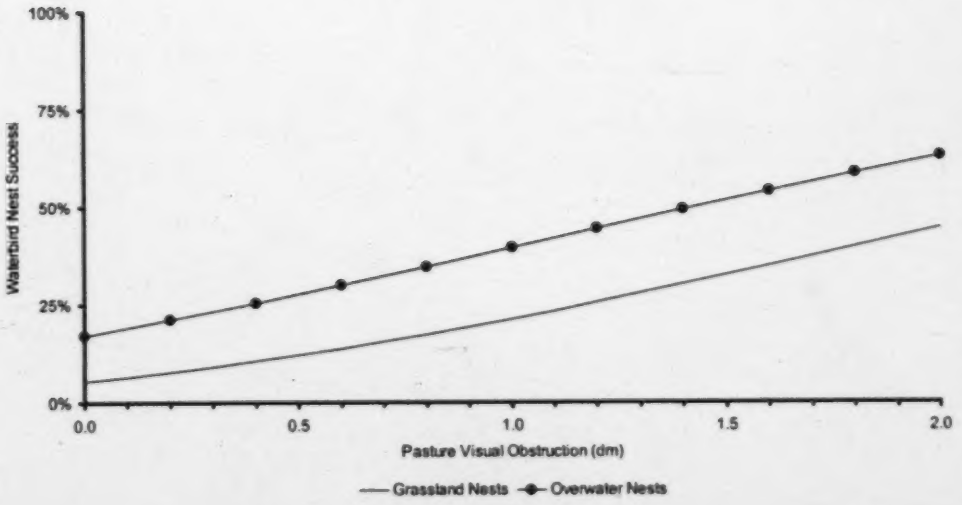

Figure 10: Predicted nest survival of waterbirds nesting in wetlands within pastures in the Aspen Parkland. Nest survival of waterbirds was higher for overwater nests in relation to grassland nests and was positively correlated to increased height and density of upland cover. The other parameter included in the model (WAREA) was set to an average value, and predictions of nest survival were averaged over cover types to create this plot.

6.0 DISCUSSION

6.1 Breeding Species Richness

Richness of breeding wetland bird species was affected by habitat characteristics at local and landscape scales. Wetland size impacted breeding species richness as increased structural complexity, deeper water levels, and greater dispersion opportunities for individuals probably reduced inter-species competition for forage and nesting sites (Brown and Dinsmore 1986, Krasowski and Nudds 1986, Fairbairn and Dinsmore 2001b). The effect of wetland size was most evident when comparing relatively small wetlands (i.e. 1 to 2 ha), and tended to diminish as wetland size increased.

Higher breeding species richness was observed during the second year of the study. Although several factors likely differ between field seasons, I suggest that the strongest difference was wetland availability during spring migration. The second field season (2002) had substantially better wetland conditions in spring due to a heavy, late-season snowfall in combination with a rapid thaw that flooded basins with resultant runoff. Better spring wetland conditions across the Parkland was likely the leading factor responsible for higher species richness estimates during the second year of the study (Swanson and Duebbert 1989).

Semi-permanent wetlands consistently attracted more bird species, as a result of greater vegetation diversity. During years of normal precipitation patterns, semi-permanent wetlands inherently have a greater degree of structural complexity than seasonal wetlands (Kantrud and Stewart 1984). Perching and nesting sites offered by cattail or bulrush (*Scirpus spp.*) offers additional breeding opportunities for species such as red-winged blackbirds and yellow-headed blackbirds. Aspen stands are commonly

associated with more permanent wetlands in the Parkland, which also extends breeding and foraging opportunities to species that prefer a mosaic of wetland, grassland and woodland habitats such as tree swallows, bufflehead or other cavity nesting birds (Stauffer and Best 1980). Semi-permanent ponds are typically deeper than seasonal ponds (Stewart and Kantrud 1971) which would be attractive to several waterbird species such as canvasbacks, American coots and grebes (Krasowski and Nudds 1986, Sutherland and Maher 1987, Barnes and Nudds 1990). The attractiveness of semi-permanent ponds is strongly exacerbated during periods of drought, as birds shift to more permanent ponds (Kantrud and Stewart 1984).

Vegetation height and density (PVOR) in pastures was an important factor in determining BSR. Across both pasture types (native and tame), BSR of wetland birds increased in a linear fashion with residual pasture cover readings. These findings agree with previous studies conducted in Alberta's Parkland that indicated peak species richness of grassland birds coincided with peak stand-productivity (Prescott and Murphy 1995, Prescott and Murphy 1996). Similar studies conducted in other grassland communities also support predictions of greater bird species richness in tall or dense stands of vegetation (Prescott and Wagner 1996, McMaster and Davis 2001).

In contrast to my predictions, it is interesting to note that pasture type (native vs. tame) did not affect richness of breeding wetland birds. Native (including naturalized) pastures contained a substantial shrub community in upland vegetation. In contrast, upland portions of tame pastures are largely devoid of shrubs as a result of periodic tillage. I expected native pastures to be more attractive to wetland birds because of increased structural heterogeneity of upland vegetation, however this response was not

observed. Although tame pastures are periodically tilled, the area immediately surrounding seasonal and semi-permanent wetlands is largely protected from agricultural activity, due to impediment of cultivation by saturated soils. As a result, shrub communities adjacent to some wetlands in tame pastures remain relatively intact and are therefore likely to be structurally similar to those occurring in wetland margins occupying native pastures. Consequently, I believe the lack of response by wetland birds to pasture type was probably a result of similarities in the structure of vegetation communities within wetland margins, despite strong differences in adjacent upland cover.

The proportion of buffers occupied by grassland area at 1 km was identified as a positive predictor of BSR. Whited et al. (2000) linked connectedness of grassland habitat surrounding wetlands to species richness of wetland birds. Similarly, Herkert (1994) found that grassland birds preferred large patches of grassland relative to small patches of grassland that were otherwise structurally similar. In Herkert's study, species richness decreased with patch size, probably as a result of reduced quantity of habitat (Herkert 1994). Therefore, I suspect nest site selection is influenced by broad landscape characteristics, in addition to quality of habitat at the patch scale. For this reason, increased conversion of cropland to pasture (i.e. greater perennial cover) is probably beneficial to wetland birds in the Parkland.

6.2 Blackbird Nest Density

Size and permanence of wetlands influenced nest density of blackbirds. Blackbirds selected semi-permanent wetlands over seasonal ponds for nesting habitat, presumably due to the availability of cattail or bulrush plant communities on which they construct nests (Willson 1966; Albers 1978). As wetland size increased however, I found

proportionally fewer blackbird nests. This probably reflects disproportionate gains to available nesting cover as larger, deeper ponds tend to have relatively smaller emergent communities (Fairbairn and Dinsmore 2001b).

Cattle activity within wetlands marginally affected blackbird nest site selection, producing small density peaks within wetlands that were moderately disturbed by cattle activity. Sedges (*Carex spp.*) and grasses that compete with cattail for resources are impacted more severely by cattle activity, as soil disruption by hoof action is most intense in shallow or dry portions of the basin. Increased siltation from soil disruption and fertilization from cattle also favors cattail growth (Swanson and Duebbert 1989, Martin and Chambers 2001). Expansion of cattail stands associated with moderate activity likely elicits a positive response by blackbirds.

Blackbirds avoided areas of high woodland density. Model selection predicted a negative response to increased woodland density at a variety of scales. This pattern may reflect avoidance of heavily wooded landscapes because they are potential havens for predators (Møller 1988). Burger (et al., 1994) reported high depredation rates on artificial nests that were located in highly fragmented prairie systems in close proximity to woodland habitats. Although Burger's work focussed on artificial ground nests, it does highlight increased predation risk associated with woodland habitats. Alternatively, blackbirds may be selecting habitat that is more open, or more closely associated with cropland as a food source.

6.3 Blackbird Nest Survival

As is typical of many nest success studies, I found a small positive effect of calendar date on survival rates of blackbird nests. The timing of nest initiation produces

this positive effect on nest survival, possibly because of variations in predation, improved physical condition of birds, and enhanced concealment of the nest though growth of vegetation (Klett and Johnson 1982). Increased numbers of emerging insects later in the breeding season as food for nestlings may also increase nestling survival (Orians 1980). The effect of increased survival over time implies a direct benefit for those birds that delay nesting until late in the season. However, because many nests fail during each breeding season, the probability of each female successfully rearing at least one brood, increases with the number of re-nesting attempts. Since optimal breeding conditions are somewhat ephemeral, it makes sense for birds to initiate as early and therefore as often during the breeding season as possible, to increase the likelihood of reproductive success.

Blackbird nests located in flooded vegetation further from shore had higher survival rates. Although avian nest predators are equally adept at accessing all portions of wetland habitats, deep water associated with increased distance to shore makes foraging difficult for mammalian predators (Picman et al. 1993, Schafer 1996). Nests constructed further from shore (i.e. over deep water) would also be increasingly protected from cattle, as cattle more commonly access shallow sites. Disruption of vegetation providing cover for nests would be minimized at greater distances from shore.

Steady declines in blackbird nest survival were noted as wetland degradation from cattle increased (Fig. 6). Trampling of substrates and the associated knocking over of stems that support nests could partially explain reduced success. Increased visibility of nests combined with increased access opportunities afforded by trampling may also be important. Negative impacts of cattle activity would be especially important for blackbirds nesting close to shore.

Although nest densities of blackbirds were positively associated with increased stand height, nest success rates were reduced when nest site vegetation was tall. This may be a reflection of the predator community that was most limiting to blackbirds in the Parkland. Although predators of individual songbird nests are difficult to identify (Pietz and Gransfors 2000), black-billed magpies and American crows were probably responsible for destroying most of the unsuccessful blackbird nests given their prevalence in the Parkland (Johnson et al. 1988, Pasitschniak-Arts and Messier 1995). Field staff routinely observed corvids roosting in trees near blackbird colonies throughout the study. Marsh wrens have also been identified as important blackbird nest predators (e.g. Picman and Isabelle 1995), however observations of marsh wrens during the study were very infrequent. Nests constructed in tall stands were probably detected at a higher rate by avian predators due to ease of detection. Given the drought conditions that prevailed in the Parkland in 2001 and 2002, tall dense cattail communities were less abundant, which probably concentrated corvids on the few ponds that remained wet.

The probability of blackbird nest survival increased as colony size increased, most likely because it was more difficult for predators to enter large colonies undetected. Predation is the factor that is most limiting to survival of blackbird nests (Orians 1961). Nest predation usually occurs while parents are foraging away from the nest (Picman and Isabelle 1995). The threat of nest predation is reduced when neighboring parents mob potential predators at nests that are unattended (Picman and Isabelle 1995). As colony size increases, vigilance by neighbors increases, and predators are more easily detected and repelled (Picman et al. 2002).

Nest survival of blackbirds was highest in ponds that had an open water zone, surrounded by a band of emergent vegetation (cover type 3; Stewart and Kantrud 1971). This result may be a function of preferred nesting habitat (and therefore increased defence by a large colony) as well as lower drought risk in deeper ponds.

Blackbird nests that were active when wetlands dried up almost always failed (personal observation). Many nest abandonments coincided with wetland drying, most likely as a result of reduced food availability (Orians 1980). Predation rates from mammalian predators increased as well. On several occasions, fresh tracks of canids were observed on mud flats close to depredated nests.

Isolation of wetlands negatively impacted blackbird nest survival rates. Schafer (1996) found similar trends in her study, and proposed that this was a function of predator foraging efficiency. Isolated wetlands are likely to be searched more intensively by predators (Burger et al. 1994). In contrast, wetlands occurring within a complex reduce foraging efficiency of predators (Pasitschniak-Arts and Messier 1995). This effect would be enhanced by increased availability of alternate prey (e.g. small mammals, other birds and nests), which may be more limited in isolated wetlands, but abundant in wetland complexes (Johnson et al. 1988).

6.4 Other Songbird Nest Density

Nest density of other songbirds was similar in native and tame pastures. However, I observed a different response to grazing intensity within each pasture type (Fig. 7). Within native stands, other songbirds strongly preferred to nest in emergent vegetation in moderately grazed pastures, in comparison to idled / lightly grazed or heavily grazed pastures. Surprisingly however, wetlands surrounded by moderately grazed and heavily

grazed tame pastures were equally attractive. The majority of literature available for grassland birds suggests reduced nest densities of songbirds in relation to cattle grazing (Naugle et al. 2000) however, many of these studies have focused primarily on upland, rather than wetland habitats. Although my findings appear to be contradictory, they may actually support previously observed trends. Fondell and Ball (2004) indicate the availability of nesting sites to be important considerations for nest density (i.e. more nests will be found in habitat that offers more nesting sites). With regards to patterns that were observed in this study, it seems likely that I found fewer nests in emergent cover in idled or lightly grazed pastures (both native and tame) as a result of greater dispersion of nests. Where habitat quality was high at the pasture level (i.e. in idled or lightly grazed pastures), birds probably maximized spatial separation by choosing to nest within a broad area across upland and wetland habitats in both native and tame pastures. Conversely, upland habitat in native or tame pastures that was moderately grazed might have fewer available nesting sites relative to plant communities in highly productive wetlands. In this situation, nest densities of other songbirds might be disproportionately higher in emergent plant communities, as birds sacrifice spatial separation for improved nesting cover in remnant patches (i.e. emergent communities).

Differences in nest density of other songbirds were observed between native and tame pastures that were heavily grazed. As grazing intensity in tame pastures increased from moderate to heavy, I found similar estimates of nest density. However a sharp decline in nest density occurred in native stands as grazing intensity shifted from moderate to heavy. The differential response of birds to heavy grazing in native and tame pastures might result from differences in forage selection by cattle, plant growth trends,

production capabilities, and topographical differences between native and tame pastures in the Aspen Parkland (Mueggler 1965, Holechek et al. 1998, Asamoah 2002)

Relative to native graminoids (e.g. rough fescue), tame grasses (e.g. *Bromus* spp) in the Parkland are generally more palatable to cattle early in the grazing season and can be more productive (herbage yields per ha) during peak songbird breeding, particularly in response to heavy rainfall (Bork et al. 2001), occasional fertilization by ranchers (McCartney 1993), and regrowth of previously clipped stems (Holechek et al. 1998). Because of this, cattle may be more likely to graze in upland plant communities more consistently throughout spring and summer in tame pastures, and are therefore less likely to access forage in wetlands (however, see Asamoah 2002). In native pastures however, upland plant communities tend to initiate growth later in spring, relative to wetland plant communities (Asamoah 2002) and have relatively low regrowth potential. Dense shrub and aspen communities in native Parkland also reduce the amount of available herbage for cattle. In contrast, wetland plants remain highly palatable well into summer (Asamoah 2002), providing quality forage for cattle once upland resources have been depleted. For this reason, cattle that are allowed to heavily graze native pastures may be more likely to forage within wetland communities in early spring during peak songbird breeding, and then again during late summer and fall.

Tame pastures in the Parkland usually occupy relatively flat terrain, and exist as a result of the ease in which tillage and re-seeding using heavy machinery can be used. Contrasting this, native pastures usually include steep hills and rough terrain that are relatively inaccessible to farm equipment. As a result of more extreme topography, native pastures have remained largely intact or have been allowed to return to a natural

state. The ease in which cattle can access forage throughout pastures is also influenced by topography. Given choice, cattle tend to avoid steep inclines (Mueggler 1965) and concentrate in lowland areas including wetlands (Willms 1988). Therefore, as an artifact of tillage history and inherent topography, wetland areas in native pastures might receive disproportionately higher grazing pressure relative to wetlands within tame pastures.

Nest densities of other songbirds were positively related to increased woodland area in 4 km buffers. Although risk of nest predation may increase in association with woody cover (Burger et al. 1994, Naugle et al. 2000, Fletcher and Koford 2002), trends towards increased nest density of other songbirds may be driven by relatively high numbers of clay-colored sparrow nests. This species is attracted to woodlands as a result of preference for nesting in grass near the base of small trees or shrubs (Owens and Myres 1973; Johnson 1996, this study).

6.5 Other Songbird Nest Survival

Whether the effect of calendar date is positive or negative on daily nest survival remains somewhat equivocal (Mayfield 1975). Several authors have indicated that nest survival rates will vary with date as a result of nesting stage (i.e. incubation vs. nestling) due to increased defence or increased conspicuousness from tending parents, changes in predator community, availability of alternate prey, more favourable weather, differences between experienced and inexperienced nesters, and changes in vegetative cover (Mayfield 1975, Johnson 1979, Best and Stauffer 1980, Klett and Johnson 1982). In this study, marginal gains in nest survival rates of other songbird nests coincided with later nest initiation, similar to the effect observed for blackbirds. The positive effect of date on survival was probably related to increases in vegetative cover, given the high productivity

of riparian vegetation (Asamoah 2002). Because of the relatively fast rate at which wetland plants grow, concealment from predators would also be rapidly enhanced. As was described earlier (see Blackbird Nest Survival), the probability of individual females successfully rearing offspring increases with multiple re-nesting attempts as the breeding season unfolds, offsetting the relatively high rate of nest failure observed in early spring.

Increased survival rates of other songbird nests were observed as a function of structural changes within emergent plant communities (i.e. WTREND, Fig. 8b). Gains to the physical structure of cover (i.e. in the absence of heavy grazing) positively affected nest survival of other songbirds, especially within idled or lightly grazed pastures. Within these pasture types, ground-based predators would have considerably more high quality habitat in which to forage, thereby reducing risk of predation to individual nests (Johnson et al. 1988, Schafer 1996). In addition, increased cover can impede predation efficiency of avian predators and movements of smaller mammalian predators (Dwernychuk and Boag 1972, Schrank 1972, Sugden and Beyersbergen 1987, Pasitschniak-Arts and Messier 1995). These effects, in addition to increased concealment of individual nests, are probably the primary reasons for improved nest survival in relation to emergent plant height gains.

Within native stands, ground nesting songbirds preferred to nest in emergent vegetation in moderately grazed pastures. In tame pastures, equal preference was evident for wetlands in moderately grazed and heavily grazed pastures. Although birds nested in higher density in wetlands exposed to moderate or heavily grazing, these may be sink habitats. Nest survival rates were lowest in moderately grazed pastures, and only marginally higher in heavily grazed pastures. The highest levels of nest survival occurred

in wetlands surrounded by idle or lightly grazed pastures. Other songbirds likely concentrate nesting efforts in emergent cover when uplands are degraded (i.e. as described above), but predators are also more likely to forage in relatively intact emergent communities in a heavily grazed pasture. For this reason, individual nests located within idled or lightly grazed systems are less prone to be depredated, because of the increased complexity of habitat in which a predator must forage.

Other songbirds nests had higher survival rates in wetlands that received high indices of cattle activity, which is counter-intuitive to what might be expected. However, Fondell and Ball (2004) and Jensen (et al. 1990) reported only minor losses due to direct trampling of nests by livestock. The timing of cattle activity may have preceded nest site selection by several other birds, resulting in the selection of sites that are outside of impacted areas, or are somehow protected from cattle activity (e.g. being placed under a fallen log). Furthermore, other songbirds may actually select hoof prints in which to nest, as these sites are often well concealed from predators.

Nest survival of other songbirds declined in response to increased proportion of open water, probably as a result of increased predator foraging efficiency. Predators are known to forage extensively within wetland areas (Pasitschniak-Arts and Messier 1995, Lariviere and Messier 2000) as a learned response to high densities of prey items (Lariviere and Messier 1998). Wetlands that have higher proportions of open water probably act to concentrate predators' foraging efforts in peripheral emergent communities where songbirds (other than blackbirds) commonly nest.

6.6 Waterbird Nest Density

Waterbirds most often selected nest sites in semi-permanent wetlands rather than seasonal ponds (Table 13). Of Parkland wetlands, seasonal and semi-permanent ponds are typically selected by breeding waterfowl as foraging and nesting habitat (Swanson and Duebbert 1989). In this study, dabbling ducks (blue-winged teal, gadwall, mallard, northern shoveler used seasonal and semi-permanent ponds in approximately equal proportions, whereas diving ducks (canvasback, lesser scaup, redhead, and ruddy duck preferred to nest in semi-permanent ponds. Similarly, American coot, black tern, horned grebe and sora were more strongly associated with semi-permanent ponds, probably because of reduced predation risk associated with deep water (Johnson and Dinsmore 1986, Sutherland and Maher 1987, Barnes and Nudds 1990). Under drought conditions, dabbling ducks shift towards use of semi-permanent wetlands (Stewart and Kantrud 1973, Krapu et al. 1997). This general pattern was observed in my study, where I found 72 (96% of total sample) diving duck, grebe and coot nests within semi-permanent ponds, and similarly high proportions (30, 70% of total sample) of dabbling ducks.

Waterbird nest density declined as the proportion of woody habitat in pastures increased (Table 13). Although some dabbling ducks (e.g. mallard, blue-winged teal) may preferentially select nest sites in association with woody cover (Dwyer 1970, Howerter 2003), I suspect that avoidance of forested pastures observed for waterbirds is driven by comparatively large numbers of diving ducks, grebes and coots, which avoid wooded cover because it may inhibit take offs of species with higher wing loading (Dwyer 1970). Furthermore, many waterbirds may avoid ponds that are associated with

trees as a learned response to increased risk of avian predation (Greenwood et al. 1987, Sutherland and Maher 1987, Burger et al. 1994).

Waterbirds preferentially nested in wetlands surrounded by native grasses (Table 13, Fig. 9). Previous studies are somewhat equivocal with respect to preference for native or tame grasses (Greenwood et al. 1987, Klett et al. 1988, Sankowski et al. 1990), however, the majority of previous research focussed on upland nesting dabbling ducks.

Highest nest densities occurred in wetlands that were moderately disturbed by cattle (Fig. 11). This pattern is consistent with results obtained by Bue et al. (1952), who observed greater densities of breeding waterfowl in relation to light to moderate cattle activity around stock ponds in South Dakota. Low to moderate levels of disturbance within shallow emergent zones, and nutrient input from cattle waste may stimulate growth of relatively intact emergent vegetation stands in deeper water (Swanson and Duebbert 1989, Popolizio et al. 1994, Martin and Chambers 2001). These emergent communities are often used for construction of overwater nesting platforms and for the concealment of broods. My sample, which included primarily overwater nests, may therefore be biased towards selection of moderately degraded sites by overwater nesters because of improved nesting and brooding habitat.

6.7 Waterbird Nest Survival

Waterbird nests constructed over water were more successful (46%) than nests constructed over dry ground (24%; Table 16). This observation is consistent with other studies (Krasowski and Nudds 1986), and suggests that overwater nests are less susceptible to predation, presumably due to impediment of access from terrestrial

predators by water (Sutherland and Maher 1987, Swanson and Duebbert 1989, Barnes and Nudds 1990).

Nests located in ponds exhibiting cover types 1 and 3 were more successful in comparison to cover type 2 ponds. This pattern was probably driven by the nesting habits of diving waterbirds, which overwhelmingly opted to nest over deep water in cover type 3 wetlands (60 nests) compared to cover type 2 (12 nests) or cover type 1 (0 nests) wetlands. Preference for cover type 3 ponds is likely driven by enhanced food resources (Kaminski and Prince 1981, Murkin et al. 1981), predator avoidance (Sutherland 1991), or consideration for brood concealment (Swanson and Duebbert 1989). Although I found relatively few dabbling duck nests in cover type 1 wetlands (5 nests), high success in these ponds (Table 16) was probably related to reduced foraging efficiency of predators in structurally complex and large wetlands (Pasitschniak-Arts and Messier 1995). However, specific causes for differences in predation between cover types is not well understood (Swanson and Duebbert 1989).

Waterbird nest survival improved as total wetland area increased. Lariviere and Messier (1988) found reduced predation pressure in areas of low nest density. Relatively large patches that hold low nest numbers are searched less efficiently (Pasitschniak-Arts and Messier 1995) and subsequently less often by predators in response to low reward (Lariviere and Messier 1988).

Survival rates of waterbird nests improved with increased residual cover of upland vegetation surrounding wetlands (Fig. 10). Much of the available literature indicates upland stand height and density positively affects duck nest density and nest success (e.g. Kirsch 1969, Barker et al. 1990, Naugle et al. 2000, Fondell and Ball 2004; however see

Sargeant and Arnold 1984, McKinnon and Duncan 1999). Predation risk for dabbling ducks that nest over dry ground increases with increased proximity to emergent vegetation (Howerter 2003), because predators may learn from past success in foraging within isolated patches of quality habitat (Lariviere and Messier 1998). Pastures that have tall, dense upland vegetation may also contain a relatively well dispersed predator community, which could relax predation pressure in emergent zones. Predation by corvids may also be less intense within lightly grazed or idled pastures, as these predators tend to be more closely associated with short plant communities where prey are primarily detected visually (Lariviere and Messier 1988).

7.0 MANAGEMENT IMPLICATIONS & RESEARCH RECOMMENDATIONS

Although heavy grazing disrupted breeding activity of wetland birds, light to moderate grazing appeared beneficial to many bird taxa. Wetlands occurring in pastures that maintained high residual cover (i.e. lightly or moderately grazed) were more likely to have greater numbers of breeding bird species, compared to wetlands that were surrounded by uplands having little or no residual cover (i.e. heavily grazed). Retaining upland cover in the spring was also important to songbirds (excluding blackbirds), as it factored heavily in determining nesting patterns and nest survival. Songbirds nested at low densities within wetlands that were part of light or moderately grazed uplands. Members of this group probably dispersed throughout the entire pasture when favourable habitat conditions existed to maximize spatial separation. Conversely, as upland habitat was degraded (i.e. as heavy grazing reduced nesting cover), songbird nest density increased in wetland margins. Under these circumstances, songbirds probably sacrificed spatial separation in favour of nesting within remnant patches of quality nesting cover

(i.e. in relatively intact wetlands). However, additional research should occur to confirm this possibility. Songbird nest survival was highest in wetlands in idled or lightly grazed pastures. Moreover, daily survival rates improved as vegetation in emergent communities was allowed to grow (i.e. in absence of heavy grazing). This trend was consistent throughout idled or lightly grazed pastures, moderately grazed pastures and heavily grazed pastures that were rested in early spring during peak songbird breeding.

Survival of waterbird nests in wetlands increased in relation to greater residual cover of upland vegetation. Nest predator activity was likely reduced in wetlands adjacent to uplands having high residual cover as a function of greater dispersal of predators, and impediment of activity due to dense plant cover. This hypothesis was not specifically tested during this study however, and should be investigated further.

Although heavy cattle activity on saturated soils negatively impacted wetland birds, light or moderate activity was not detrimental. In some circumstances, cattle activity benefited nesting birds. Blackbirds and waterbirds nested at higher densities within wetlands that received moderate disturbance by cattle, probably as a result of indirect benefits from cattle activity. Moderate disturbance of soils and vegetation within peripheral wetland zones likely left flooded emergent vegetation communities (i.e. cattail and bulrush) relatively intact, which is where blackbirds and most waterbirds constructed overwater nests. Furthermore, siltation from soil disruption and nutrient inputs from cattle waste within peripheral zones probably enhanced emergent communities over time, creating more nesting sites for blackbirds and waterbirds that nest overwater. Although I observed greater nest density of waterbirds in wetlands that were moderately impacted by cattle activity, I suspect that this trend was driven largely by a sample that was biased

towards overwater nests. Subsequently, it remains unclear how cattle activity affects waterbirds that nest in dry emergent cover.

Although blackbirds nested at high densities in wetlands that were moderately impacted by cattle activity, nest survival declined as activity indices increased. As activity increases, cattle probably wade deeper into cattail and bulrush stands. Increased movement by cattle in these communities directly impacts nests as supporting stems are knocked over. Furthermore, nests that are not directly damaged by cattle activity may be more visible to avian predators as surrounding cover is destroyed.

In comparison to land-use practices (e.g. annual crop) that reduce availability of wetlands, or limit the amount of perennial cover at the landscape scale, maintaining well-managed pasture is strongly favoured for successful management of wetland bird communities. Several strategies that are commonly employed for good pasture management are also favourable to breeding wetland birds. Rest-rotational or deferred grazing (Holechek et al. 1998) practices that maintains residual vegetation through winter and early spring enhances snow capture, increases soil moisture, and allows for retention of carbohydrate reserves by individual plants for vigorous growth in the following growing season. In addition, residual vegetation (i.e. litter) that is available in early spring provides important nesting cover and protection from predators for nesting birds. Furthermore, deferred grazing allows grass and other forage to recover energy and store carbohydrates while simultaneously increasing concealment for bird nests.

Although cattle are attracted to and therefore concentrate near wetlands (Fitch and Adams 1998), there are several steps producers can take to minimize damage to wetlands. As a first step, reduction of stocking rates in heavily grazed pastures is strongly

recommended to balance forage availability with animal needs. Moreover, reducing demand for forage will relieve pressure throughout upland and wetland plant communities, and will decrease grazing intensity. Increased distribution of livestock is also important to wetland protection and can be inexpensively attained through strategic placement of salt and mineral supplements. By placing salt and mineral supplements in underutilized areas such as hilltops and areas of pasture that are far away from water sources, cattle are encouraged to grazed a broad area more evenly, and will consequently spend less time in or near wetlands. The development of off-site watering facilities that deliver water from a dugout or well to a tank or waterer also encourages cattle to avoid wetlands. Although implementation of off-site waterers can be costly, benefits accrued from enhanced rate gains in calves typically offset initial expenses (Anonymous 1997). The development of grazing systems (e.g. rest-rotation, deferred rotation) will also protect wetlands by introducing a period of rest to paddocks and associated wetlands. As a last resort, wetlands that have been heavily degraded or are susceptible to chronic visitation by cattle may require long-term exclusion fencing to physically prevent cattle from entering them.

8.0 LITERATURE CITED

ADAMS, B.W., A. ROBERTSON, M. WILLOUGHBY, G. EHLERT, M. ALEXANDER, D. DOWNING, D.LAWRENCE, C. LANE, AND C. STONE. 2000. Range/Pasture Health Assessment Short Form. Alberta Rangeland Health Task Group, unpublished report.

AGRICULTURE AND AGRI-FOOD CANADA. 1995. Agriculture and Agri-Food Canada 1995 Prairie Landcover. Agriculture and Agri-Food Canada unpublished report.

AGRICULTURE AND AGRI-FOOD CANADA. 2001. Agriculture and Agri-Food Canada Drought Watch. http://www.agr.gc.ca/pfra/drought/index_e.htm.

ALBERS, P.H. 1978. Habitat selection by breeding red-winged blackbirds. Wilson Bulletin 90:619–634.

ANONYMOUS. 1997. Managing Saskatchewan Rangeland. Grazing and Pasture Technology Program, Regina, SK. 99 pp.

ANONYMOUS. 2001. Livestock grazing and riparian areas: A literature review. Grazing and pasture technology program. Regina, Saskatchewan.

ASAMOAH, S. A. 2002. Seasonal herbage dynamics and utilization by yearlings on a native Aspen Parkland riparian landscape in central Alberta. M.S. Thesis. University of Alberta, Edmonton, Alberta, Canada.

_____, E.W. BORK, B.D. IRVING, M.A. PRICE, AND R.J. HUDSON. 2003. Cattle herbage utilization patterns under high-density rotational grazing in the Aspen Parkland. Canadian Journal of Animal Science 83: 541-550.

_____, _____, _____, _____, and _____. 2004 Seasonal; herbage dynamics on Aspen Parkland landscapes in central Alberta. Canadian Journal of Animal Science 84: 149-153.

BAICICH, P.J. AND C.J.O. HARRISON. 1997. A guide to the nests, eggs, and nestlings of North American Birds. 2nd ed. Academic Press. San Diego, CA.

BARKER, W.T., K.K. SEDIVEC, T.A. MESSMER, K.F. HIGGINS, AND D.R. HERTEL. 1990. Effects of specialized grazing systems on waterfowl production in southcentral North Dakota. Transactions of the 55th North American Wildlife and Natural Resources Conference.

BARNES, G.G., AND T.D. NUDDS. 1990. Temporal variation in microhabitat relationships among grebes and coots. Wilson Bulletin 102(1):99 – 108.

BERENDSE, F., M.J.M. OOMES, H.J. ALTENA, AND W.TH. ELBERSE. 1992. Experiments on the restoration of species-rich meadows in The Netherlands. Biological Conservation 62: 59-65.

BEST, L.B. AND D.F. STAUFFER. 1980. Factors affecting nesting success in riparian bird communities. Condor 82:149-158.

BORK, E.W., T. THOMAS, AND B. MCDOUGALL. 2001. Herbage response to precipitation in central Alberta boreal grasslands. Journal of Range Management 54:243-248.

BOWEN, B.S., AND A.D. KRUSE. 1993. Effects of grazing on nesting by upland sandpipers in southcentral North Dakota. Journal of Wildlife Management 57(2):291-301.

BOYCE, M.S., D.I. MACKENZIE, B.F.J. MANLY, M.A. HAROLDSON, AND D. MOODY. 2001. Negative binomial models for abundance estimation of multiple closed populations. Journal of Wildlife Management 65(3): 498-509.

BROWN, M., AND J.J. DINSMORE. 1986. Implications of marsh size and isolation for marsh bird management. Journal of Wildlife Management 50(3):392-397.

BUE, I.G., L. BLANKENSHIP, AND W.H. MARSHALL. 1952. The relationship of grazing practices to waterfowl breeding populations and production on stock ponds in western South Dakota. Transactions of the North American Wildlife Conference 17:396 – 414.

BURGER, L.D., L.W. BURGER, AND J. FAABORG. 1994. Effects of prairie fragmentation on predation on artificial nests. Journal of Wildlife Management 58:249-254.

BURNHAM, K.P., AND D.R. ANDERSON. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York, New York, USA.

CHORNEY, B., AND R. JOSEPHSON. 2000. A survey of pasture management practices on the Canadian prairies with emphasis on rotational grazing and managed riparian areas. Department of Agriculture Economics and Farm Management, Faculty of Agriculture and Food Sciences, University of Manitoba

DALE, B.C. 1993. Saskatchewan non-game bird evaluation of North American Waterfowl Management Plan – DNC and short grass cover. Saskatchewan Wetland Conservation Corporation.

DALE, B.C., P.A. MARTIN, AND P.S. TAYLOR. 1997. Effects of hay management on grassland songbirds in Saskatchewan. Wildlife Society Bulletin 25(3):616-626.

DAUBENMIRE, R.K. 1959. A canopy-coverage method of vegetation analysis. Northwest Science 33:43-64.

DINSMORE, S.J., G.C. WHITE, AND F.L. KNOPF. 2002. Advanced techniques for modeling avian survival. Ecology 83(12):3476 – 3488.

DOUGLAS, D.C., J.T. RATTI, R.A. BLACK, AND J.R. ALLDREDGE. 1992. Avian habitat associations in riparian zones of Idaho's Centennial Mountians. Wilson Bulletin 104(3): 485-500.

DUCKS UNLIMITED. 2002. The effects of grazing management on habitat quality and waterfowl production: An annotated bibliography. Unpublished

DUEBBERT, H.F., E.T. JACOBSON, K.F. HIGGINS, AND E.B. PODOLL. 1981. Establishment of seeded grasslands for wildlife habitat in the prairie pothole region. U. S. Fish and Wildlife Service Special Scientific Report, Wildlife No. 234. 21pp.

DWERNYCHUK, L.W., AND D.A. BOAG. 1972. How vegetation cover protects duck nests from egg-eating birds. Journal of Wildlife Management 36:955-958.

DWYER, D.D., J.C. BUCKHOUSE, AND W.S. HUEY. 1984. Impacts of grazing intensity and specialized grazing systems on the use and value of rangeland: Summary and recommendations. Pp. 867-884 In B.D. Gardner, chair., Developing strategies for rangeland management: A report prepared by the Committee on Developing Strategies for Rangeland Management of the National Research Council/National Academy of Science. Westview Press, Boulder CO.

DWYER, T.J. 1970. Waterfowl breeding habitat in agricultural and non-agricultural land in Manitoba. Journal of Wildlife Management 34(1):130 – 136.

EHRHART, R.C. AND P.L. HANSEN. 1997. Effective cattle management in riparian zones: A field survey and literature review. United States Department of Interior, Bureau of Land Management, Montana State Office. Missoula, Montana. Riparian Technical Bulletin No. 3. 92 pp.

ENVIRONMENT CANADA 1996. The state of Canada's Environment. Gilmore Printing; Gloucester, ON.

EULISS, N. H. JR., D. M. MUSHET, AND D. A. WRUBLESKI. 1999. Wetlands of the Prairie Pothole Region: Invertebrate species composition, ecology, and management. Pp. 471-514 In D. P. Batzer, R. B. Rader and S. A. Wissinger, eds. Invertebrates in Freshwater Wetlands of North America: Ecology and Management, Ch. 21. John Wiley & Sons, New York.

FAIRBAIRN, S.E, AND J.J. DINSMORE. 2001a. Factors associated with occurrence and density of wetland birds in the Prairie Pothole Region of Iowa. Journal of Iowa Academy of Science 108(1):8-14.

FAIRBAIRN, S.E. AND J.J. DINSMORE. 2001b. Local and landscape-level influences on wetland bird communities of the prairie pothole region of Iowa, USA. Wetlands 21(1):41-47.

FITCH, L. AND B.W. ADAMS. 1998. Can cows and fish co-exist? Canadian Journal of Plant Science 78:191-198.

FLEISCHNER, T.L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8(3):629-644.

FLETCHER, R.J. AND R.R. KOFORD. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. Journal of Wildlife Management 66(4):1011-1022.

FONDELL, T.F., AND J.J. BALL. 2004. Density and success of bird nests relative to grazing on western Montana grasslands. Biological Conservation 117:203-21.

GIBBS, J.P., AND MELVIN, S.M. 1993. Call-response surveys for monitoring breeding birds. Journal of Wildlife Management 57 (1):27-34.

GJERSING, F.M. 1975. Waterfowl production in relation to rest-rotation grazing. Journal of Range Management 28(1):37-42.

GLOUTNEY, M.L., R.G. CLARK, A.D. AFTON, AND G.J. HUFF. 1993. Timing of nest searches for upland nesting waterfowl. Journal of Wildlife Management 57:597-601.

GREENWOOD, R.J., A.B. SARGEANT, D.H. JOHNSON, L.M. COWARDIN, AND T.L SHAFFER. 1987. Mallard nest success and recruitment in Prairie Canada. Transactions of the North American Wildlife and Natural Resources Conference 52:298 – 309.

HERKERT, J. R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4(3):461-471.

HIGGONS, K.F., AND W.T. BARKER. 1982. Changes in vegetation structure in seeded nesting cover in the prairie pothole region. U. S. Fish and Wildlife Service Special Scientific Report, Wildlife No. 242. 26pp.

HOLECHEK, J.J., R.D. PIEPER, AND C.H. HERBEL. 1998. Range Management: Principles and practices. 3rd ed. Prentice-Hall, Inc. Upper Saddle River, New Jersey, USA.

HOWERTER, D. W. 2003. Factors affecting duck nesting in the Aspen Parklands: A spatial analysis. PhD Dissertation, Montana State University, Bozeman, USA.

HUTTO, R.L., S.M. PLETSHET, AND P. HENDRICKS. 1986. A fixed-radius point count method for non-breeding and breeding season use. Auk 103:593-602.

JEFFERSON, P.G., L. WETTER, AND B. WARK. 1999. Quality of deferred forage from waterfowl nesting sites on the Canadian Prairies. Canadian Journal of Animal Science 79: 485-490.

JENSON, H.P., D. ROLLINS, AND R.L. GILLEN. 1990. Effects of cattle stock density on trampling loss of simulated ground nests. Wildlife Society Bulletin 18:71-74.

JOHNSON, D.H. 1979. Estimating nest success: The Mayfield method and an alternative. Auk 96(4):651 – 661.

_____, A.B. SARGEANT, AND R.J. GREENWOOD. 1988. Importance of individual species of predators on nesting success of ducks in the Canadian Prairie Pothole Region. Canadian Journal of Zoology 67:291-297.

_____. 1996. Management of northern prairies and wetlands for the conservation of neotropical migratory birds. Pp. 53-67 In F.R. Thompson, III, ed. Management of midwestern landscapes for the conservation of neotropical migratory birds. U.S. Department of Agriculture, Forest Service, General Technical Report NC-187. North Central Forest Experiment Station, St. Paul.

JOHNSON, R.R., AND J.J. DINSMORE. 1986. Habitat use by breeding virginia rails and soras. Journal of Wildlife Management 50(3):387 – 392.

KAMINSKI, R.H., AND H.H. PRINCE. 1981. Dabbling duck and aquatic macroinvertebrate responses to manipulated wetland habitat. Journal of Wildlife Management 45:1 – 15.

KANTRUD, H.A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. The Canadian Field Naturalist 95:404-417.

_____ AND STEWART R.E. 1984. Ecological distribution and crude density of breeding birds on prairie wetlands. Journal of Wildlife Management 48(2):426-437.

KIRSCH, L.M. 1969. Waterfowl production in relation to grazing. Journal of Wildlife Management 33(4):821-828.

KLETT, A.T., AND D.H. JOHNSON. 1982. Variability in nest survival rates and implications to nesting studies. Auk 99:77-87.

_____, H.F. DUEBBERT, C.A. FAANES, AND K.F. HIGGINS. 1986. Techniques for studying nest success of ducks in upland habitats in the Prairie Pothole Region. U.S.F.W.S. Resource Publication.

_____, T.L. SHAFFER, AND D.H. JOHNSON. 1988. Duck nest success in the prairie pothole region. Journal of Wildlife Management 52:431 – 440.

KNOPF, F.L., J.A. SEDGEWICK AND R.W. CANNON. 1988. Guild structure of a riparian avifauna relative to seasonal cattle grazing. Journal of Wildlife Management 52(2):280-290.

KRAPU, G.L., R.J. GREENWOOD, C.P. DWYER, K. M. KRAFT, AND L.M. COWARDIN. 1997. Wetland use, settling patterns, and recruitment in Mallards. Journal of Wildlife Management 61(3):736 – 746.

KRASOWSKI, T.P., AND T.D. NUDDS. 1986. Microhabitat structure of nest sites and nesting success of diving ducks. Journal of Wildlife Management 50(2):203 – 208.

KRUSE, A.D., AND B.S. BOWEN. 1996. Effects of grazing and burning on densities and habitats of breeding ducks in North Dakota. Journal of Wildlife Management 60(2):233-246.

LARIVIERE, S., AND F. MESSIER. 1998. Effect of density and nearest neighbors on simulated waterfowl nests: Can predators recognize high-density nesting patches? Oikos 83(1):12-20.

LARIVIERE, S., AND F. MESSIER. 2000. Habitat selection and use of edges by striped skunks in the Canadian prairies. Canadian Journal of Zoology 78:366–372.

LOKEMOEN, J.T. AND R.R. KOFORD. 1996. Using candlers to determine the incubation stage of passerine eggs. Journal of Field Ornithology 67(4):660-668.

MARLOW, C.B. AND T.M. POGACNIK. 1986. Cattle feeding and resting patterns in a foothills riparian zone. Journal of Range Management 39(3):212-217.

MARTIN, D.W., AND J.C. CHAMBERS. 2001. Restoring degraded riparian meadows: Biomass and species responses. Journal of Range Management 54: 284-291.

MARTIN, T.E., AND G.R. GUEPEL. 1993. Protocols for nest monitoring plots: Locating nests, monitoring success, and measuring vegetation. Journal of Field Ornithology 64:507-519.

_____, C.R. PAINE, C.J. CONWAY, W.M. HOCHACHKA, P.ALLEN AND W.JENKINS. 1997. BBIRD Field Protocol. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana, USA.

MAYFIELD, H.F. 1975. Suggestions for calculating nest success. Wilson Bulletin 87 (4):456 – 466.

MCCARTNEY, D.H. 1993. History of grazing research in the Aspen Parkland. Canadian Journal of Animal Science 73:749-763.

McKinnon, D.T., and D.C. Duncan. 1999. Effectiveness of dense nesting cover for increasing duck production in Saskatchewan. Journal of Wildlife Management 63(1):382-389.

McMaster, D.G., and S.K. Davis. 2001. An evaluation of Canada's Perennial Cover Program: Habitat for grassland birds? Journal of Field Ornithology 72(2):195-210.

Møller, A.P. 1988. Nest predation and nest site choice in passerine birds in habitat patches of different size: A study of magpies and blackbirds. Oikos 53: 215-221.

Mueggler, W.F. 1965. Cattle distribution on steep slopes. Journal of Range Management. 18:255 – 257.

Murkin, H.R., R.M. Kaminski, and R.D. Titman. 1981. Responses by dabbling ducks and aquatic invertebrates to an experimentally manipulated cattail marsh. Canadian Journal of Zoology 60:2324 – 2332.

Naugle, D.E., K.E. Higgins, S.M. Nasser and W.C. Johnson. 1999. Scale-dependent habitat use in three species of prairie wetland birds. Landscape Ecology 14:267-276.

_____, _____, and K.K. Bakker. 2000. A synthesis of the effects of upland management practices on waterfowl and other birds in the northern Great Plains of the U.S. and Canada. College of Natural Resources, University of Wisconsin-Stevens Point, WI. Wildlife Technical Report 1. 28 pp.

Olson, B.D. 1994. Alberta's prairie vegetation: Past and present use. Rangelands 16 (2):58-62.

Orians, G.H. 1961. The ecology of blackbird (Agelaius) social systems. Ecological Monographs 31: 285-312.

Orians, G.H. 1980. Some adaptations of marsh-nesting Blackbirds. Princeton University Press. Princeton, New Jersey, USA.

Owens, R.A., and M.T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Canadian Journal of Zoology 51: 697-713.

Pasitschniak-Arts, M. and F. Messier. 1995. Risk of predation on waterfowl nests in the Canadian prairies: Effects of habitat edges and agricultural practices. Oikos 73:347 – 355.

Picman, J., and A. Isabelle. 1995. Sources of nesting mortality and correlates of nesting success in yellow-headed blackbirds. Auk 112(1):183 – 191.

_____,S. PRIBIL, AND A. ISABELLE. 2002. Antipredation value of colonial nesting in yellow-headed blackbirds. The Auk 119(2):461-472.

_____, M.L. MILKS, AND M. LEPTICH. 1993. Patterns of predation on passerine nests in marshes: effects of water depth and distance from edge. Auk 110:89-94.

PIETZ, P.J. AND D.A. GRANFORS. 2000. Identifying predators and fates of grassland passerine nests using miniature video cameras. Journal of Wildlife Management 64(1):71-87.

POPOLIZIO, C.A., H. GOETZ, AND P.L. CHAPMAN. 1994. Short-term response of riparian vegetation to 4 grazing treatments. Journal of Range Management 47:48-53.

POPOTNIK, G.J., AND W.M. GIULIANO. 2000. Response of birds to grazing of riparian zones. Journal of Wildlife Management 64 (4):976-982.

PRESCOTT, D.R.C., AND A.J. MURPHY. 1995. Bird populations and vegetation structure of tame dense nesting cover (DNC) in Alberta's Aspen Parkland. Alberta NAWMP Centre. NAWMP-014. Edmonton, Alberta. 19 pp.

_____, A.J. MURPHY, AND E. EWASCHUK. 1995. An avian community approach to determining biodiversity values of NAWMP habitats in the Aspen Parkland of Alberta. Alberta NAWMP Centre. NAWMP-012. Edmonton, AB. 58pp.

_____, AND A. J. MURPHY. 1996. Habitat associations of grassland birds on native and tame pastures in the Aspen Parkland of Alberta. Alberta NAWMP Centre. NAWMP-021. Edmonton, AB. 36pp.

_____, AND G.M. WAGNER. 1996. Avian responses to implementation of a complementary/rotational grazing system by the North American Waterfowl Management Plan in southern Alberta: The Medicine Wheel Project. Alberta NAWMP Centre. NAWMP-018. Edmonton, AB. 24pp.

_____, B.C. DALE, AND R.D. DICKSON. 1998. Effects of timing and intensity of grazing on nest success of upland-nesting birds on the University Ranch. Land Stewardship Centre of Canada and Canadian Wildlife Service. NAWMP-034. Edmonton, AB. 30pp.

ROBEL, R. J., J. N. BRIGGS, A. D. DAYTON, AND L. C. HURLBERT. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. J. Range Manage. 23:295-297.

SANKOWSKI, T., M. HAYWORTH-BROCKMAN, AND B. JOYNT. 1990. Evaluation of waterfowl nesting success in a rest-rotation grazing system in southern Alberta. Ducks Unlimited Unpublished Report.

SAS INSTITUTE. 2001. SAS/STAT user's guide. Version 8.2. Sas Institute, Cary North Carolina, USA.

SARGEANT, A.B., AND P.M. ARNOLD. 1984. Predator management for ducks on waterfowl production areas in the northern plains. Proceedings of the Vertebrate Pest Conference 59:328 – 336.

SCHAFER, J.L. 1996. A comparison of blackbird reproductive success in natural and restored Iowa wetlands. M.S. Thesis. Iowa State University, Ames, IA, USA.

SCHICK, C.D. 1972. A documentation and analysis of wetland drainage in the Alberta Parkland. Canadian Wildlife Service, Environment Canada. Unpublished report. Edmonton.

SCHRANK, B.W. 1972. Waterfowl nest cover and some predation relationships. Journal of Wildlife Management 36:182-186.

SEVERSON, K.E., AND C.E. BOLDT. 1978. Livestock grazing: A tool to improve wildlife habitat. Pp. 232-249 In Ecological implications of livestock herbivory in the west. M.Vavra, W.A. Laycock, and R.D. Pieper eds. Society for Range Management, Denver CO. 297 pp.

SKOVLIN, J.M. 1984. Impacts of grazing on wetlands and riparian habitat: A review of our knowledge. Pp. 1001-1103 In Developing strategies for range management. Westview Press: Boulder, CO.

STATISTICS CANADA. 2001. 2001 census: census of agriculture. Statistics Canada, Ottawa, Ontario, Canada. http://www.statcan.ca/english/census01/agri.htm.

STAUFFER, D.F., AND L.B. BEST. 1980. Habitat selection by birds of riparian communities: Evaluating effects of habitat alterations. Journal of Wildlife Management 44(1):1-15.

STEPHENS, S.E., D.N. KOONS, J.J. ROTELLA, AND D.W. WILLEY. 2003. Effects of habitat fragmentation on avian nesting success: a review of the evidence at multiple spatial scales. Biological Conservation 115: 101-110.

STEWART, R.E., AND H.A. KANTRUD. 1971. Classification of natural ponds and lakes in the glaciated pothole region. U.S.F.W.S. Resource Publication 92.

_____, AND _____. 1973. Ecological distribution of breeding waterfowl populations in North Dakota. Journal of Wildlife Management 37(1):39-50.

STRONG, W. L., B. K. CALVERLY, A. J. RICHARD, AND G. R. STEWART. 1993. Characterization of wetlands in the settled areas of Alberta. Alberta Environmental Protection, Unpublished report. Edmonton. 143p.

_____., and K.R. Leggat. 1992. Ecoregions of Alberta. Alberta Forestry, Lands, and Wildlife, Edmonton, Alberta, Canada. Publication T/245.

SUGDEN, L.G., AND G.W. BEYERSBERGEN. 1987. Effects of nesting cover density on American crow predation on simulated duck nests. Journal of Wildlife Management 51:481-485.

SUTHERLAND, J.M., AND W.J. MAHER. 1987. Nest site selection of the American Coot in the Aspen Parkland of Saskatchewan. Condor 89:804 – 810.

_____ 1991. Effects of drought on American Coot, Fulica americana, reproduction in Saskatchewan parklands. Canadian Field-Naturalist 105(2):267 – 273.

SWANSON, G.A., AND H.F. DUEBBERT. 1989. Wetland habitats of waterfowl in the prairie pothole region. Pp. 228-267 In A.G. Van der Valk, ed. Northern Prairie Wetlands. Iowa State University Press, Ames.

TAYLOR, D.M. 1986. Effects of cattle grazing on passerine birds nesting in riparian habitat. Journal of Range Management 39 (3):254-258.

VAN DER VALK, A.G., AND C.B. DAVIS. 1978. The role of seed banks in the vegetation dynamics of prairie glacial marshes. Ecology 59: 322-335.

VENABLES, W.N., AND B.D. RIPLEY. 2002. Modern applied statistics with S. 4th edition. Springer-Verlag, New York, New York, USA.

WARREN, J.M. 2004. Effects of cattle grazing on upland nesting duck production in the Aspen Parkland. M.Sc. Thesis. Montana State University, Bozeman, Montana.

WELLER, M.W. 1956. A simple field candler for waterfowl eggs. Journal of Wildlife Management 20(2):111-113.

WELLER, M.W., AND C.E. SPATCHER. 1965. Role of habitat in the distribution and abundance of marsh birds. Iowa Agricultural Home Economics Experimental Station Special Report No. 43.

WESTERSKOV, K. 1950. Methods for determining the age of game bird eggs. Journal of Wildlife Management 14:56-67.

WHITE, G.C., AND R.E. BENNETS. 1996. Analysis of frequency count data using the negative binomial distribution. Ecology 77(8):2549-2557.

WHITED, D., S. GALATOWITSCH, J.R. TESTER, K. SCHIK, R.LEHTINEN, AND J. HUSVETH. 2000. The importance of local and regional factors in predicting effective conservation planning strategies for wetland bird communities in agricultural and urban landscapes. Landscape and Urban Planning 49:49-65.

WILLMS, W.D. 1988. Forage production and utilization in various topographic zones of the Fescue Grasslands. Canadian Journal of Animal Science 68:211-223.

WILLSON, M.F. 1966. Breeding ecology of the yellow-headed blackbird. Ecological monographs 36:51-77.

WINTER, T. C. 1989. Hydrologic studies of wetlands in the northern prairie. Pp. 16 - 55 In Northern Prairie Wetlands A. G. van der Valk, ed. Iowa State University Press, Ames.

Appendix 1: Study site locations, characteristics, and covariates used to study effects of grazing on wetland birds in the Aspen Parkland of Alberta, 2001 and 2002. Independent variables and covariate abbreviations and definitions can be found in Table 1.

Site	Year	Cluster	Legal Land Location	BARE	COVER	COVSHB	COVTRE	DISTASP	DISTWET	LNWAREA
Ames – 24	2002	BAE	NE9-42-20-W4	0.21	3	0.63	0.15	0.00	163.02	0.62
Ames – 26	2002	BAE	NE9-42-20-W4	0.07	3	0.85	0.00	0.00	51.99	0.33
Ames – 30	2002	BAE	NE9-42-20-W4	0.07	3	0.98	0.15	0.00	51.99	0.23
B&E Lease – 46	2001	PLW	NW16-35-25-W4	0.27	3	0.00	0.00	171.68	58.94	-0.98
B&E Lease – 66	2001	PLW	NW16-35-25-W4	0.06	3	0.03	0.00	101.18	50.38	-0.13
Barritt Lease - 03	2002	ALX	NE2/SW11-40-22-W4	0.14	3	0.03	0.00	20.88	94.91	-1.10
Barritt Lease - 14	2002	ALX	NE2/SW11-40-22-W4	0.03	1	0.00	0.85	0.00	23.98	-0.09
Basilian – 01	2002	MUN	SW/SE9-53-16-W4	0.05	3	0.15	0.15	0.00	53.64	-0.79
Basilian – 38	2002	MUN	SW/SE9-53-16-W4	0.06	3	0.38	0.63	0.00	14.08	-0.66
Basilian – 75	2002	MUN	SW/SE9-53-16-W4	0.07	1	0.85	0.03	17.06	13.36	0.51
Basilian – 97	2002	MUN	SW/SE9-53-16-W4	0.06	1	0.38	0.15	0.00	21.54	-0.16
Behnke – 12	2002	BL2	NW33-46-22-W4	0.07	3	0.00	0.03	11.22	89.44	-0.34
Behnke – 16	2002	BL2	NW33-46-22-W4	0.17	3	0.00	0.15	0.00	25.86	-0.47
Berger – 01	2002	BL2	SE8/NE5-47-22-W4	0.30	3	0.00	0.85	0.00	42.90	0.34
Berger – 27	2002	BL2	SE8/NE5-47-22-W4	0.05	3	0.03	0.00	9.79	41.78	-1.41
Berger – 30	2002	BL2	SE8/NE5-47-22-W4	0.36	3	0.00	0.00	7.44	21.30	-0.54
Berger – 32	2002	BL2	SE8/NE5-47-22-W4	0.07	3	0.00	0.00	53.50	100.39	-0.58
Best – 04	2002	ROV	SW13-49-23-W4	0.01	3	0.00	0.03	0.00	65.55	0.57
Best – 10	2002	ROV	SW13-49-23-W4	0.16	3	0.00	0.00	164.45	63.50	-0.91
Bilan – 16	2002	BVN	NE17-53-19-W4	0.28	2	0.85	0.00	0.00	14.05	-2.43
Bilan – 19	2002	BVN	NE17-53-19-W4	0.16	2	0.63	0.00	0.00	0.00	0.23
Bilan – 22	2002	BVN	NE17-53-19-W4	0.32	1	0.85	0.00	0.00	15.94	-1.75
Bilan – 29	2002	BVN	NE17-53-19-W4	0.15	3	0.85	0.15	0.00	41.15	0.43
Bosma – 28	2001	LAP	SW12-40-20-W4	0.26	3	0.00	0.00	252.50	196.27	0.44
Bosma – 30	2001	LAP	SW12-40-20-W4	0.33	3	0.63	0.00	0.00	88.75	-0.16
Brimacombe26 - 15	2002	SL2	NW26-41-22-W4	0.09	2	0.63	0.15	0.00	86.71	-0.49
Brimacombe26 - 19	2002	SL2	NW26-41-22-W4	0.06	3	0.85	0.63	0.00	23.21	-0.44
Brimacombe34 - 07	2002	BAE	NE34-41-21-W4	0.39	3	0.15	0.00	130.64	12.39	-0.52
Brimacombe34 - 18	2002	BAE	NE34-41-21-W4	0.11	3	0.15	0.00	115.23	43.04	-0.24
Brimacombe34 - 22	2002	BAE	NE34-41-21-W4	0.27	3	0.03	0.15	0.00	11.70	0.47
Brosinsky – 15	2001	CAS	SE2-42-20-W4	0.26	3	0.85	0.63	0.00	0.00	0.03
Brosinsky – 29	2001	CAS	SE2-42-20-W4	0.13	3	0.63	0.38	0.00	107.86	-0.80
Brownlee – 10	2001	MLK	SW7-51-19-W4	0.41	3	0.15	0.00	84.32	0.00	-0.35
Brownlee – 18	2001	MLK	SW7-51-19-W4	0.07	3	0.15	0.00	0.00	52.71	-1.26
Cha – 09	2001	BLK	SE35-46-21-W4	0.18	2	0.00	0.00	418.70	16.08	0.92

Site	Year	Cluster	Legal Land Location	BARE	COVER	COVSHB	COVTRE	DISTASP	DISTWET	LNWAREA
Cha - 14	2001	BLK	SE35-46-21-W4	0.39	3	0.00	0.00	578.33	19.02	0.54
CJohnson - 12	2002	BL2	SW11-46-23-W4	0.16	2	0.38	0.00	97.24	10.89	0.24
Cole&Rhymer - 03	2001	RDL	SE30-45-22-W4	0.14	3	0.63	0.38	0.00	38.53	0.28
Cole&Rhymer - 11	2001	RDL	SE30-45-22-W4	0.05	3	0.15	0.00	141.99	14.50	-0.55
CollinsCrown - 10	2001	PLE	SE29-35-23-W4	0.04	3	0.98	0.15	0.00	51.10	-1.01
CollinsCrown - 20	2001	PLE	SE29-35-23-W4	0.07	3	0.63	0.63	0.00	0.00	-0.36
Cossey - 14	2002	BVN	NE27-53-18-W4	0.39	3	0.15	0.15	10.26	40.95	0.18
Crown - 04	2002	ALX	NW/NE11-39-23-W4	0.26	2	0.63	0.00	0.00	22.38	0.86
Crown - 08	2002	ALX	NW/NE11-39-23-W4	0.16	2	0.63	0.00	47.11	20.23	-0.72
Crown - 20	2002	ALX	NW/NE11-39-23-W4	0.19	3	0.98	0.63	0.00	83.41	0.59
Dahl - 35	2001	PLE	NE18-36-23-W4	0.30	3	0.03	0.38	0.00	43.69	0.10
Dahl - 51	2001	PLE	NE18-36-23-W4	0.45	3	0.00	0.00	0.00	67.60	-0.48
Dawson - 01	2001	RDL	NW/NE16-43-21-W4	0.26	3	0.00	0.00	0.00	35.50	-0.33
Dawson - 08	2001	RDL	NW/NE16-43-21-W4	0.51	3	0.00	0.00	0.00	0.00	0.52
DUC-Andrews - 03	2001	RDL	NE14-42-21-W4	0.45	3	0.15	0.00	0.00	21.43	-0.34
DUC-Andrews - 03	2002	BAE	NE14-42-21-W4	0.00	3	0.15	0.00	0.00	21.43	-0.34
DUC-Andrews - 07	2002	BAE	NE14-42-21-W4	0.08	3	0.15	0.03	0.00	32.69	0.31
DUC-Andrews - 36	2001	RDL	NE14-42-21-W4	0.44	3	0.00	0.15	74.33	32.69	-0.71
DUC-Beck - 15	2001	BLK	NE15-47-21-W4	0.09	3	0.00	0.38	0.00	19.35	-1.13
DUC-Beck - 15	2002	BL2	NE15-47-21-W4	0.02	3	0.00	0.38	0.00	19.35	-1.13
DUC-Beck - 18	2001	BLK	NE15-47-21-W4	0.03	1	0.03	0.15	0.00	48.92	0.71
DUC-Beck - 18	2002	BL2	NE15-47-21-W4	0.09	2	0.03	0.03	0.00	48.92	0.71
DUC-Blaikie - 03	2001	PLE	NW35-36-24-W4	0.09	3	0.98	0.15	0.00	84.73	-0.05
DUC-Blaikie - 05	2001	PLE	NW35-36-24-W4	0.06	3	0.85	0.38	0.00	27.69	-1.06
DUC-Bluesky - 13	2001	BLK	NE29-46-21-W4	0.00	3	0.03	0.00	0.00	15.08	-1.52
DUC-Bluesky - 13	2002	BL2	NE29-46-21-W4	0.26	3	0.38	0.00	0.00	15.08	-1.52
DUC-Bluesky - 46	2001	BLK	NE29-46-21-W4	0.05	3	0.38	0.15	0.00	35.46	0.40
DUC-Bluesky - 46	2002	BL2	NE29-46-21-W4	0.12	3	0.38	0.15	0.00	35.46	0.40
DUC-Boyden - 02	2001	PLE	SE11-36-23-W4	0.00	3	0.15	0.38	0.00	43.76	0.00
DUC-Boyden - 15	2001	PLE	SE11-36-23-W4	0.03	3	0.00	0.00	11.05	20.25	-0.29
DUC-Caine - 12	2002	BAE	NE6-41-19-W4	0.17	3	0.38	0.38	0.00	92.19	0.77
DUC-Caine - 14	2002	BAE	NE6-41-19-W4	0.13	2	0.00	0.38	0.00	66.57	-0.72
DUC-Dochstader - 14	2002	MUN	NE7-53-16-W4	0.00	3	0.85	0.00	29.26	4.03	0.26
DUC-Hawthorne - 02	2001	SLK	NW24-38-24-W4	0.17	3	0.38	0.00	0.00	0.00	0.46
DUC-Hawthorne - 02	2002	ALX	NW24-38-24-W4	0.02	3	0.38	0.00	0.00	0.00	0.47
DUC-Hawthorne - 18	2001	SLK	NW24-38-24-W4	0.12	3	0.38	0.00	0.00	0.00	0.99
DUC-Hawthorne - 18	2002	ALX	NW24-38-24-W4	0.17	3	0.38	0.00	0.00	0.00	-0.44
DUC-Johnson - 05	2002	BL2	SE29-46-22-W4	0.00	3	0.03	0.00	73.81	55.67	0.13

Site	Year	Cluster	Legal Land Location	BARE	COVER	COVSHB	COVTRE	DISTASP	DISTWET	LNWAREA
DUC-Johnson - 22	2002	BL2	SE29-46-22-W4	0.00	3	0.03	0.00	0.00	38.89	0.50
DUC-Johnson - 33	2002	BL2	SE29-46-22-W4	0.07	2	0.00	0.00	179.92	3.80	-1.24
DUC-Lawson - 09	2001	LAP	SE32-40-20-W4	0.20	3	0.38	0.63	0.00	67.28	-0.03
DUC-Lawson - 09	2002	BAE	SE32-40-20-W4	0.03	3	0.38	0.63	0.00	67.28	0.28
DUC-Lawson - 10	2001	LAP	SE32-40-20-W4	0.15	3	0.38	0.15	0.00	68.14	-0.02
DUC-Lawson - 10	2002	BAE	SE32-40-20-W4	0.00	3	0.38	0.15	0.00	68.14	-0.55
DUC-Lyseng - 16	2001	MLK	SW24-48-21-W4	0.15	3	0.00	0.38	0.00	0.00	-0.59
DUC-Lyseng - 17	2001	MLK	SW24-48-21-W4	0.08	3	0.00	0.00	33.82	80.62	-2.15
DUC-Nixon - 20	2001	CAS	NE15-41-19-W4	0.00	1	0.03	0.00	116.29	85.14	-1.68
DUC-Nixon - 31	2001	CAS	NE15-41-19-W4	0.15	3	0.15	0.38	0.00	19.86	0.79
DUC-Siemens - 03	2002	SL2	SW33-42-21-W4	0.39	3	0.00	0.03	0.00	22.49	-1.09
DUC-Siemens - 15	2002	SL2	SW33-42-21-W4	0.29	3	0.03	0.63	0.00	75.00	-0.83
DUC-Siemens - 27	2002	SL2	SW33-42-21-W4	0.03	3	0.00	0.00	38.63	66.50	0.41
DUC-Stauffer - 06	2002	SL2	NE/NW4-43-21-W4	0.16	3	0.03	0.00	112.12	41.33	-0.12
DUC-Stauffer - 28	2002	SL2	NE/NW4-43-21-W4	0.24	3	0.38	0.00	0.00	4.86	0.84
DUC-Stauffer - 31	2002	SL2	NE/NW4-43-21-W4	0.07	3	0.00	0.15	53.23	37.07	-0.58
DUC-Thompson - 22	2001	CAS	SE34-41-22-W4	0.63	3	0.00	0.00	145.18	5.83	0.49
DUC-Thompson - 33	2001	CAS	SE34-41-22-W4	0.12	3	0.03	0.00	84.67	22.25	0.22
DUC-Vanguard - 03	2002	ML2	NW23-48-21-W4	0.12	1	0.03	0.00	136.97	73.45	-2.13
DUC-Vanguard - 08	2002	ML2	NW23-48-21-W4	0.11	3	0.00	0.00	165.51	23.98	-1.51
DUC-Vanguard - 10	2002	ML2	NW23-48-21-W4	0.00	2	0.00	0.00	97.08	11.03	-1.96
DUC-Wik - 02	2001	PLE	SE32-35-24-W4	0.12	3	0.00	0.00	169.58	18.41	-1.80
DUC-Wik - 15	2001	PLE	SE32-35-24-W4	0.14	3	0.03	0.00	165.00	72.51	-0.83
DUC-Willy - 01	2002	BAE	SE31-40-21-W4	0.11	3	0.98	0.63	0.00	9.11	-0.14
DUC-Willy - 02	2002	BAE	SE31-40-21-W4	0.11	3	0.85	0.03	7.73	0.00	-0.18
DUC-Willy - 04	2002	BAE	SE31-40-21-W4	0.09	3	0.85	0.03	4.39	13.86	0.41
Fankhanel - 21	2001	CAS	NE/SE29-42-20-W4	0.03	3	0.00	0.00	23.91	32.98	-1.08
Fankhanel - 25	2001	CAS	NE/SE29-42-20-W4	0.14	3	0.00	0.63	0.00	53.90	0.51
Felt – 04	2002	SL2	SE5-42-22-W4	0.11	3	0.63	0.63	0.00	20.96	-0.99
Felt – 19	2002	SL2	SE5-42-22-W4	0.15	3	0.63	0.63	0.00	54.24	-0.84
Frerefarms - 34	2001	PLE	NW3-36-23-W4	0.33	3	0.15	0.38	0.00	41.27	-0.16
Frerefarms - 61	2001	PLE	NW3-36-23-W4	0.48	2	0.85	0.38	0.00	43.54	0.20
Gloria Lease - 02	2001	PLW	NW35-35-25-W4	0.03	2	0.00	0.85	0.00	21.97	-0.84
Gloria Lease - 12	2001	PLW	NW35-35-25-W4	0.03	1	0.38	0.00	0.00	95.60	-0.72
Hagstrom - 11	2002	ROV	SW31-47-22-W4	0.01	3	0.00	0.00	409.43	8.42	-0.17
Hagstrom - 31	2002	ROV	SW31-47-22-W4	0.16	3	0.38	0.38	0.00	60.66	1.47
Hagstrom - 81	2002	ROV	SW31-47-22-W4	0.07	3	0.15	0.03	50.33	6.85	0.65
Hilson Investments - 07	2001	BLK	NW22-46-22-W4	0.52	3	0.00	0.03	89.13	56.46	0.81

Site	Year	Cluster	Legal Land Location	BARE	COVER	COVSHB	COVTRE	DISTASP	DISTWET	LNWAREA
Hilson Investments -11	2001	BLK	NW22-46-22-W4	0.51	3	0.00	0.15	0.00	56.46	0.19
Hofstra - 18	2002	ROV	NW11-48-23-W4	0.24	3	0.38	0.15	60.37	19.88	-1.02
Hofstra - 27	2002	ROV	NW11-48-23-W4	0.21	2	0.15	0.00	68.29	4.32	-0.67
Hofstra - 29	2002	ROV	NW11-48-23-W4	0.13	3	0.63	0.15	0.00	7.37	-0.10
Jensen - 04	2001	SLK	SW18-41-22-W4	0.44	3	0.38	0.00	27.23	62.34	-0.52
Jensen - 30	2001	SLK	SW18-41-22-W4	0.00	1	0.03	0.03	0.00	21.85	-0.09
Klassen - 02	2001	RDL	NE15-44-22-W4	0.05	3	0.63	0.63	0.00	0.00	1.01
Klassen - 08	2001	RDL	NE15-44-22-W4	0.09	3	0.15	0.63	0.00	0.00	2.01
Krause - 32	2001	PLW	NE31-35-25-W4	0.31	3	0.38	0.85	0.00	73.41	0.30
Krause - 54	2001	PLW	NE31-35-25-W4	0.32	3	0.85	0.38	0.00	40.16	-0.15
Lakeview - 02	2001	MLK	NE7-49-20-W4	0.14	3	0.85	0.85	0.00	102.57	-0.19
Lazari - 07	2002	ML2	SE35-48-20-W4	0.32	1	0.85	0.38	0.00	102.51	0.48
Lazari - 08	2002	ML2	SE35-48-20-W4	0.13	3	0.38	0.85	0.00	102.51	0.40
MacNaughton - 06	2001	LAP	NW/NE11-40-19-W4	0.24	3	0.63	0.63	19.05	76.54	0.23
MacNaughton - 47	2001	LAP	NW/NE11-40-19-W4	0.52	3	0.98	0.63	0.00	66.70	0.65
Matson - 04	2002	ML2	NW25-48-21-W4	0.04	2	0.15	0.85	0.00	83.46	-0.77
Matson - 07	2002	ML2	NW25-48-21-W4	0.37	2	0.03	0.00	0.00	65.60	-1.09
Matson - 20	2002	ML2	NW25-48-21-W4	0.31	3	0.03	0.15	0.00	6.14	-1.58
Mayowski - 02	2002	BVN	NW36-53-19-W4	0.16	2	0.85	0.38	0.00	21.52	0.05
Mayowski - 12	2002	BVN	NW36-53-19-W4	0.21	3	0.85	0.15	33.40	0.00	0.70
Mayowski - 15	2002	BVN	NW36-53-19-W4	0.07	1	0.00	0.00	84.92	9.45	0.34
McKinney - 05	2002	ROV	NE17-48-23-W4	0.06	3	0.03	0.00	145.28	28.61	-0.69
McKinney - 09	2002	ROV	NE17-48-23-W4	0.09	3	0.03	0.00	222.20	61.89	-0.93
McKinney - 28	2002	ROV	NE17-48-23-W4	0.14	3	0.85	0.15	0.00	4.59	-0.37
Miquelon - 07	2001	MLK	NE/SE33-49-20-W4	0.11	3	0.03	0.00	8.59	0.00	-0.45
Miquelon - 07	2002	ML2	NE/SE33-49-20-W4	0.00	3	0.15	0.00	8.59	0.00	-0.10
Miquelon - 39	2001	MLK	NE/SE33-49-20-W4	0.09	2	0.98	0.15	0.00	6.30	-0.69
Miquelon - 39	2002	ML2	NE/SE33-49-20-W4	0.04	2	0.63	0.38	0.00	6.30	0.18
Montgomery - 03	2001	LAP	NW21-42-19-W4	0.26	3	0.00	0.15	0.00	14.15	-1.09
Montgomery - 25	2001	LAP	NW21-42-19-W4	0.13	3	0.15	0.15	0.00	69.35	1.08
Moseson - 08	2001	RDL	SW27-44-22-W4	0.40	3	0.00	0.15	64.62	81.59	-0.03
Moseson - 11	2001	RDL	SW27-44-22-W4	0.17	3	0.03	0.38	0.00	0.00	0.64
Neufeld - 32	2002	BL2	SW7-48-22-W4	0.26	3	0.63	0.63	0.00	0.00	0.34
Neufeld - 37	2002	BL2	SW7-48-22-W4	0.07	3	0.98	0.98	0.00	35.00	-0.47
Neufeld - 38	2002	BL2	SW7-48-22-W4	0.06	3	0.63	0.63	6.07	68.03	0.88
Ohman Lease - 02	2001	BLK	SE5-47-22-W4	0.02	3	0.00	0.15	0.00	112.77	0.57
Ohman Lease - 30	2001	BLK	SE5-47-22-W4	0.07	3	0.00	0.15	0.00	57.11	0.41
Peters - 21	2001	LAP	SW5-40-19-W4	0.21	3	0.15	0.00	10.82	5.91	0.03

Site	Year	Cluster	Legal Land Location	BARE	COVER	COVSHB	COVTRE	DISTASP	DISTWET	LNWAREA
Peters - 28	2001	LAP	SW5-40-19-W4	0.66	3	0.15	0.15	0.00	10.20	-0.32
Plaister - 04	2001	SLK	SE14-41-23-W4	0.17	3	0.63	0.63	0.00	16.43	-0.33
Plaister - 08	2001	SLK	SE14-41-23-W4	0.28	1	0.03	0.38	0.00	28.00	-1.06
Pyramid - 13	2002	ALX	NE/SE32-39-23-W4	0.19	3	0.85	0.00	54.08	53.10	-1.46
Pyramid - 36	2002	ALX	NE/SE32-39-23-W4	0.24	3	0.98	0.63	0.00	7.39	1.37
SalmonNE - 14	2001	CAS	NE24-41-20-W4	0.21	3	0.85	0.38	0.00	43.99	-1.02
SalmonNE - 26	2001	CAS	NE24-41-20-W4	0.49	3	0.38	0.00	35.05	25.34	-1.19
SalmonSW - 01	2002	BAE	SW30-41-19-W4	0.00	3	0.38	0.00	45.62	0.00	-0.58
SalmonSW - 06	2002	BAE	SW30-41-19-W4	0.03	3	0.63	0.15	0.00	0.00	1.47
Sargeant - 36	2001	SLK	SW/NW26-40-23-W4	0.21	3	0.00	0.03	0.00	47.76	-1.11
Sargeant - 66	2001	SLK	SW/NW26-40-23-W4	0.63	3	0.00	0.38	0.00	25.84	-0.37
Schoff - 12	2001	CAS	NW17-42-20-W4	0.31	3	0.03	0.15	8.28	0.00	-0.85
Schoff - 19	2001	CAS	NW17-42-20-W4	0.13	3	0.63	0.38	0.00	0.00	-0.12
Shute - 13	2002	ML2	NW5-48-19-W4	0.45	1	0.00	0.00	17.08	161.61	0.49
Shute - 25	2002	ML2	NW5-48-19-W4	0.14	2	0.85	0.63	0.00	141.78	-0.09
Shute - 27	2002	ML2	NW5-48-19-W4	0.13	1	0.03	0.03	12.24	0.00	-0.04
Stavne - 08	2001	MLK	NW26-49-21-W4	0.06	3	0.03	0.85	0.00	7.43	-0.41
Stavne - 27	2001	MLK	NW26-49-21-W4	0.05	1	0.15	0.15	0.00	0.00	-0.35
Stavne - 27	2002	ML2	NW26-49-21-W4	0.04	1	0.63	0.38	0.00	0.00	-0.35
Stavne - 29	2002	ML2	NW26-49-21-W4	0.02	3	0.63	0.15	0.00	0.00	0.14
Stavne - 31	2002	ML2	NW26-49-21-W4	0.13	3	0.63	0.63	0.00	0.00	-0.46
Steele -10	2001	PLW	NW/NE14-37-26-W4	0.18	3	0.38	0.15	0.00	13.98	0.42
Steele -14	2001	PLW	NW/NE14-37-26-W4	0.13	2	0.03	0.03	10.99	10.33	-1.00
Stollery - 03	2001	MLK	SW19-49-20-W4	0.03	1	0.15	0.00	0.00	7.63	1.55
Stollery - 14	2001	MLK	SW19-49-20-W4	0.23	3	0.03	0.15	0.00	8.77	0.07
Walker - 01	2002	ML2	SW8-49-20-W4	0.18	3	0.38	0.38	27.84	0.00	0.85
Walker - 24	2002	ML2	SW8-49-20-W4	0.00	3	0.38	0.38	0.00	9.83	0.60
Walker - 34	2002	ML2	SW8-49-20-W4	0.09	3	0.38	0.38	0.00	15.55	-0.99
Walstrom - 15	2001	LAP	SE34-40-19-W4	0.39	3	0.98	0.15	0.00	8.87	-0.23
Walstrom - 20	2001	LAP	SE34-40-19-W4	0.57	3	0.85	0.85	0.00	0.00	-0.25
Ziegler - 12	2002	BVN	NE/SE15-53-18-W4	0.27	1	0.03	0.00	318.47	0.00	2.17
Ziegler - 19	2002	BVN	NE/SE15-53-18-W4	0.18	2	0.03	0.00	0.00	11.80	-0.28

Site	Year	MAXHGT	NPLANT	OWTR	PCLASS	PCTOPEN	SEARCH	SQRTDISTASP	SQRTDISTWET	CAI
Ames - 24	2002	0.51	26	0.51	4	0.27	4.07	0.00	12.77	3.13
Ames - 26	2002	0.36	17	0.33	4	0.23	1.90	0.00	7.21	3.33
Ames - 30	2002	0.43	35	0.20	4	0.16	2.92	0.00	7.21	3.31
B&E Lease - 46	2001	0.64	20	0.11	4	0.30	0.52	13.10	7.68	1.67
B&E Lease - 66	2001	0.66	25	0.25	4	0.28	1.26	10.06	7.10	1.00
Barritt Lease - 03	2002	0.25	12	0.00	3	0.00	0.96	4.57	9.74	3.00
Barritt Lease - 14	2002	0.40	18	0.00	4	0.00	2.73	0.00	4.90	2.50
Basilian - 01	2002	0.58	30	0.09	4	0.20	1.10	0.00	7.32	1.00
Basilian - 38	2002	0.60	22	0.08	4	0.16	1.31	0.00	3.75	1.00
Basilian - 75	2002	0.41	16	0.00	3	0.00	2.94	4.13	3.66	1.00
Basilian - 97	2002	0.50	18	0.12	4	0.14	2.19	0.00	4.64	1.75
Behnke - 12	2002	0.47	18	0.19	4	0.26	0.49	3.35	9.46	3.08
Behnke - 16	2002	0.62	21	0.11	4	0.17	1.56	0.00	5.09	3.06
Berger - 01	2002	0.30	25	0.57	4	0.41	2.49	0.00	6.55	2.92
Berger - 27	2002	0.57	14	0.08	4	0.33	0.49	3.13	6.46	2.67
Berger - 30	2002	0.31	23	0.17	4	0.29	1.23	2.73	4.62	2.83
Berger - 32	2002	0.37	18	0.04	4	0.07	1.33	7.31	10.02	2.90
Best - 04	2002	0.50	12	0.81	3	0.46	1.60	0.00	8.10	3.67
Best - 10	2002	0.44	12	0.00	3	0.00	1.21	12.82	7.97	2.88
Bilan - 16	2002	0.28	22	0.00	3	0.00	0.26	0.00	3.75	2.67
Bilan - 19	2002	0.40	20	0.12	3	0.09	1.72	0.00	0.00	3.33
Bilan - 22	2002	0.39	28	0.02	3	0.13	0.45	0.00	3.99	3.50
Bilan - 29	2002	0.46	18	0.04	4	0.02	3.95	0.00	6.41	3.67
Bosma - 28	2001	0.46	28	0.41	4	0.27	1.61	15.89	14.01	3.19
Bosma - 30	2001	0.57	19	0.45	4	0.52	0.81	0.00	9.42	2.89
Brimacombe26 - 15	2002	0.38	20	0.00	3	0.00	1.84	0.00	9.31	3.75
Brimacombe26 - 19	2002	0.38	12	0.06	3	0.09	1.75	0.00	4.82	4.00
Brimacombe34 - 07	2002	0.20	16	0.24	3	0.40	1.07	11.43	3.52	3.33
Brimacombe34 - 18	2002	0.26	20	0.00	4	0.00	2.35	10.73	6.56	3.17
Brimacombe34 - 22	2002	0.34	19	0.31	3	0.19	3.86	0.00	3.42	3.83
Brosinsky - 15	2001	0.83	19	0.19	4	0.18	1.68	0.00	0.00	3.25
Brosinsky - 29	2001	0.41	23	0.00	4	0.00	0.90	0.00	10.39	3.00
Brownlee - 10	2001	0.45	22	0.21	4	0.30	0.99	9.18	0.00	1.92
Brownlee - 18	2001	0.33	17	0.07	3	0.26	0.42	0.00	7.26	1.86
Cha - 09	2001	0.81	12	1.15	4	0.46	1.46	20.46	4.01	2.46
Cha - 14	2001	0.45	19	0.26	3	0.15	2.90	24.05	4.36	2.75
CJohnson - 12	2002	0.35	25	0.00	3	0.00	3.82	9.86	3.30	3.00
Cole&Rhymer - 03	2001	0.49	20	0.36	4	0.27	1.93	0.00	6.21	2.98

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Cole&Rhymer – 11	2001	0.59	8	0.10	3	0.17	0.96	11.92	3.81	3.17
CollinsCrown - 10	2001	0.36	24	0.00	3	0.00	0.73	0.00	7.15	2.08
CollinsCrown - 20	2001	0.51	13	0.44	4	0.63	0.24	0.00	0.00	2.67
Cossey - 14	2002	0.17	15	0.15	3	0.13	2.00	3.20	6.40	4.00
Crown - 04	2002	0.39	18	0.07	3	0.03	6.44	0.00	4.73	2.58
Crown - 08	2002	0.31	20	0.01	3	0.03	1.42	6.86	4.50	2.67
Crown - 20	2002	0.57	22	0.49	3	0.27	3.97	0.00	9.13	2.17
Dahl - 35	2001	0.38	18	0.44	4	0.39	1.35	0.00	6.61	4.00
Dahl - 51	2001	0.32	26	0.05	3	0.08	1.15	0.00	8.22	4.00
Dawson - 01	2001	0.43	22	0.11	3	0.15	0.86	0.00	5.96	1.89
Dawson - 08	2001	0.55	19	0.44	4	0.26	2.47	0.00	0.00	1.25
DUC-Andrews - 03	2001	0.68	20	0.27	4	0.38	0.88	0.00	4.63	1.22
DUC-Andrews - 03	2002	0.86	33	0.27	4	0.38	1.32	0.00	4.63	1.00
DUC-Andrews - 07	2002	0.98	26	0.61	4	0.45	1.53	0.00	5.72	1.00
DUC-Andrews - 36	2001	0.69	19	0.24	4	0.49	0.50	8.62	5.72	1.33
DUC-Beck - 15	2001	0.59	16	0.11	4	0.34	0.43	0.00	4.40	1.17
DUC-Beck - 15	2002	0.68	25	0.11	3	0.34	0.64	0.00	4.40	1.00
DUC-Beck - 18	2001	0.64	18	0.00	4	0.00	3.21	0.00	6.99	1.13
DUC-Beck - 18	2002	0.51	23	0.00	4	0.00	4.82	0.00	6.99	1.00
DUC-Blaikie - 03	2001	0.70	16	0.23	4	0.24	1.15	0.00	9.20	1.94
DUC-Blaikie - 05	2001	0.76	15	0.03	4	0.09	0.63	0.00	5.26	2.06
DUC-Bluesky - 13	2001	0.43	14	0.08	3	0.35	0.22	0.00	3.88	3.00
DUC-Bluesky - 13	2002	0.29	23	0.08	3	0.35	0.33	0.00	3.88	1.86
DUC-Bluesky - 46	2001	0.34	20	0.37	4	0.25	2.24	0.00	5.95	2.44
DUC-Bluesky - 46	2002	0.46	18	0.37	4	0.25	3.36	0.00	5.95	2.63
DUC-Boyden - 02	2001	0.37	16	0.10	4	0.10	1.13	0.00	6.62	2.89
DUC-Boyden - 15	2001	0.44	11	0.05	4	0.07	0.93	3.32	4.50	3.00
DUC-Caine - 12	2002	0.51	31	0.56	4	0.26	4.79	0.00	9.60	1.00
DUC-Caine - 14	2002	0.39	15	0.00	3	0.00	1.46	0.00	8.16	1.00
DUC-Dochstader - 14	2002	0.69	21	0.13	4	0.10	2.19	5.41	2.01	1.00
DUC-Hawthorne - 02	2001	0.60	20	0.27	4	0.17	1.40	0.00	0.00	1.00
DUC-Hawthorne - 02	2002	0.43	20	0.31	4	0.19	3.86	0.00	0.00	1.00
DUC-Hawthorne - 18	2001	0.42	23	0.20	4	0.07	1.54	0.00	0.00	1.06
DUC-Hawthorne - 18	2002	0.37	23	0.06	4	0.09	1.75	0.00	0.00	1.00
DUC-Johnson - 05	2002	0.56	24	0.25	4	0.22	1.72	8.59	7.46	1.00
DUC-Johnson - 22	2002	0.61	21	0.30	4	0.18	4.08	0.00	6.24	1.00
DUC-Johnson - 33	2002	0.59	15	0.01	3	0.05	0.82	13.41	1.95	1.00
DUC-Lawson - 09	2001	0.72	20	0.28	4	0.29	1.07	0.00	8.20	1.00

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DUC-Lawson - 09	2002	0.49	26	0.36	3	0.27	2.89	0.00	8.20	1.00
DUC-Lawson - 10	2001	0.38	17	0.53	4	0.55	0.88	0.00	8.25	1.00
DUC-Lawson - 10	2002	0.68	26	0.10	3	0.17	1.44	0.00	8.25	1.00
DUC-Lyseng - 16	2001	0.42	15	0.03	3	0.05	1.06	0.00	0.00	1.00
DUC-Lyseng - 17	2001	0.29	13	0.00	4	0.00	0.23	5.82	8.98	1.00
DUC-Nixon - 20	2001	0.41	10	0.00	3	0.00	0.37	10.78	9.23	1.00
DUC-Nixon - 31	2001	0.49	18	1.44	4	0.65	0.60	0.00	4.46	1.00
DUC-Siemens - 03	2002	0.64	20	0.05	3	0.16	0.85	0.00	4.74	3.33
DUC-Siemens - 15	2002	0.69	30	0.00	3	0.00	0.72	0.00	8.66	2.67
DUC-Siemens - 27	2002	0.42	27	0.03	3	0.02	4.42	6.22	8.15	2.11
DUC-Stauffer - 06	2002	0.77	27	0.34	4	0.39	1.63	10.59	6.43	1.00
DUC-Stauffer - 28	2002	0.66	23	0.63	4	0.27	2.18	0.00	2.20	1.00
DUC-Stauffer - 31	2002	0.72	30	0.01	3	0.02	0.72	7.30	6.09	1.00
DUC-Thompson - 22	2001	0.35	26	0.18	4	0.11	1.25	12.05	2.41	1.00
DUC-Thompson - 33	2001	0.42	26	0.15	4	0.12	1.15	9.20	4.72	1.00
DUC-Vanguard - 03	2002	0.45	14	0.00	3	0.00	0.36	11.70	8.57	1.00
DUC-Vanguard - 08	2002	0.48	18	0.00	4	0.00	0.66	12.87	4.90	1.00
DUC-Vanguard - 10	2002	0.42	18	0.00	3	0.00	0.42	9.85	3.32	1.00
DUC-Wik - 02	2001	0.60	22	0.02	4	0.13	0.29	13.02	4.29	1.83
DUC-Wik - 15	2001	0.72	17	0.13	4	0.30	0.61	12.85	8.52	2.13
DUC-Willy - 01	2002	0.30	23	0.19	4	0.22	1.92	0.00	3.02	1.00
DUC-Willy - 02	2002	0.49	17	0.23	4	0.28	1.81	2.78	0.00	1.00
DUC-Willy - 04	2002	0.28	18	0.53	4	0.35	2.58	2.10	3.72	1.00
Fankhanel - 21	2001	0.49	16	0.03	4	0.08	0.62	4.89	5.74	3.44
Fankhanel - 25	2001	0.54	18	0.12	4	0.07	0.93	0.00	7.34	3.33
Felt - 04	2002	0.35	16	0.07	4	0.18	0.91	0.00	4.58	3.63
Felt - 19	2002	0.57	25	0.08	4	0.19	1.06	0.00	7.36	3.50
Frerefarms - 34	2001	0.41	13	0.37	4	0.44	0.95	0.00	6.42	3.52
Frerefarms - 61	2001	0.48	12	0.09	4	0.08	1.77	0.00	6.60	3.58
Gloria Lease - 02	2001	0.56	15	0.06	4	0.13	0.47	0.00	4.69	1.00
Gloria Lease - 12	2001	0.41	17	0.03	3	0.07	0.91	0.00	9.78	1.00
Hagstrom - 11	2002	0.56	15	0.49	3	0.58	1.06	20.23	2.90	1.00
Hagstrom - 31	2002	0.77	28	0.69	4	0.16	8.44	0.00	7.79	1.00
Hagstrom - 81	2002	0.74	23	0.59	4	0.31	2.21	7.09	2.62	1.54
Hilson Investments - 07	2001	0.52	17	0.52	4	0.23	1.02	9.44	7.51	3.38
Hilson Investments -11	2001	0.32	25	0.50	3	0.42	1.41	0.00	7.51	3.13
Hofstra - 18	2002	0.41	29	0.11	3	0.31	0.75	7.77	4.46	3.13
Hofstra - 27	2002	0.46	31	0.03	4	0.06	1.45	8.26	2.08	3.44

Site	Year	MAXHGT	NPLANT	OWTR	PCLASS	PCTOPEN	SEARCH	SQRTDISTASP	SQRTDISTWET	CAI
Hofstra – 29	2002	0.32	26	0.18	3	0.20	1.59	0.00	2.71	2.33
Jensen - 04	2001	0.37	27	0.05	4	0.08	1.09	5.22	7.90	2.31
Jensen - 30	2001	0.42	15	0.00	3	0.00	0.90	0.00	4.67	2.83
Klassen - 02	2001	0.57	28	0.70	4	0.26	1.88	0.00	0.00	1.00
Klassen - 08	2001	0.50	24	0.33	4	0.04	2.28	0.00	0.00	1.00
Krause - 32	2001	0.43	18	0.50	3	0.37	1.69	0.00	8.57	3.33
Krause - 54	2001	0.44	16	0.55	4	0.64	0.62	0.00	6.34	3.75
Lakeview - 02	2001	0.45	15	0.06	3	0.07	1.44	0.00	10.13	2.92
Lazari - 07	2002	0.32	14	0.00	3	0.00	0.62	0.00	10.12	2.63
Lazari - 08	2002	0.48	17	0.12	3	0.08	4.10	0.00	10.12	2.88
MacNaughton - 06	2001	0.43	12	0.72	4	0.57	1.07	4.36	8.75	3.13
MacNaughton - 47	2001	0.36	7	1.05	3	0.55	1.74	0.00	8.17	3.00
Matson - 04	2002	0.58	18	0.07	4	0.15	1.19	0.00	9.14	2.25
Matson - 07	2002	0.42	19	0.00	4	0.00	0.54	0.00	8.10	3.00
Matson - 20	2002	0.50	20	0.05	3	0.25	0.46	0.00	2.48	2.97
Mayowski - 02	2002	0.51	10	0.03	4	0.03	3.07	0.00	4.64	3.67
Mayowski - 12	2002	0.34	25	0.20	4	0.10	2.51	5.78	0.00	3.56
Mayowski - 15	2002	0.44	12	0.01	4	0.01	3.79	9.22	3.07	3.78
McKinney - 05	2002	0.27	17	0.05	3	0.10	1.35	12.05	5.35	2.33
McKinney - 09	2002	0.27	24	0.08	4	0.20	0.95	14.91	7.87	3.13
McKinney - 28	2002	0.26	25	0.08	3	0.11	1.85	0.00	2.14	2.08
Miquelon - 07	2001	0.36	13	0.15	3	0.24	0.97	2.93	0.00	1.00
Miquelon - 07	2002	0.37	20	0.36	3	0.39	0.79	2.93	0.00	1.00
Miquelon - 39	2001	0.57	11	0.02	3	0.04	0.97	0.00	2.51	1.00
Miquelon - 39	2002	0.55	18	0.15	3	0.13	2.00	0.00	2.51	1.00
Montgomery - 03	2001	0.32	17	0.17	4	0.52	0.33	0.00	3.76	4.00
Montgomery - 25	2001	0.48	25	1.48	4	0.50	1.36	0.00	8.33	3.25
Moseson - 08	2001	0.29	29	0.18	4	0.19	1.13	8.04	9.03	2.25
Moseson - 11	2001	0.44	21	0.00	4	0.00	0.73	0.00	0.00	2.56
Neufeld - 32	2002	0.26	26	0.51	4	0.36	1.23	0.00	0.00	3.25
Neufeld - 37	2002	0.32	28	0.27	4	0.43	1.06	0.00	5.92	3.13
Neufeld - 38	2002	0.37	28	1.48	4	0.61	1.11	2.46	8.25	2.89
Ohman Lease - 02	2001	0.68	14	0.60	4	0.34	1.25	0.00	10.62	1.50
Ohman Lease - 30	2001	0.56	15	0.67	4	0.45	0.38	0.00	7.56	1.56
Peters - 21	2001	0.36	18	0.63	4	0.61	0.81	3.29	2.43	2.83
Peters - 28	2001	0.35	14	0.37	4	0.51	0.71	0.00	3.19	1.92
Plaister - 04	2001	0.77	26	0.11	4	0.16	0.73	0.00	4.05	2.67
Plaister - 08	2001	0.40	15	0.06	3	0.18	0.57	0.00	5.29	2.50

Site	Year	MAXHGT	NPLANT	OWTR	PCLASS	PCTOPEN	SEARCH	SQRTDISTASP	SQRTDISTWET	CAI
Pyramid – 13	2002	0.30	19	0.00	3	0.00	0.70	7.35	7.29	3.08
Pyramid - 36	2002	0.26	25	2.10	4	0.53	1.53	0.00	2.72	3.67
SalmonNE - 14	2001	0.39	11	0.10	4	0.29	0.52	0.00	6.63	3.44
SalmonNE - 26	2001	0.37	17	0.07	3	0.22	0.48	5.92	5.03	3.00
SalmonSW - 01	2002	0.52	27	0.11	3	0.20	1.23	6.75	0.00	1.00
SalmonSW - 06	2002	0.64	27	1.19	4	0.27	3.35	0.00	0.00	1.13
Sargeant - 36	2001	0.38	11	0.11	4	0.32	0.44	0.00	6.91	3.11
Sargeant - 66	2001	0.25	20	0.39	3	0.56	0.61	0.00	5.08	3.00
Schoff - 12	2001	0.35	17	0.12	4	0.27	0.62	2.88	0.00	3.13
Schoff - 19	2001	0.52	13	0.39	4	0.45	0.98	0.00	0.00	2.63
Shute - 13	2002	0.39	13	0.03	4	0.02	4.81	4.13	12.71	3.44
Shute - 25	2002	0.26	19	0.00	3	0.00	1.66	0.00	11.91	3.25
Shute - 27	2002	0.36	21	0.00	3	0.00	1.30	3.50	0.00	3.44
Stavne - 08	2001	0.31	13	0.00	4	0.00	1.33	0.00	2.73	2.50
Stavne - 27	2001	0.54	19	0.00	4	0.00	0.75	0.00	0.00	2.25
Stavne - 27	2002	0.50	28	0.00	4	0.00	1.12	0.00	0.00	3.56
Stavne - 29	2002	0.51	20	0.04	4	0.04	3.04	0.00	0.00	3.08
Stavne - 31	2002	0.36	28	0.00	3	0.00	0.95	0.00	0.00	3.06
Steele -10	2001	0.53	16	0.37	4	0.24	1.33	0.00	3.74	1.92
Steele -14	2001	0.65	16	0.00	3	0.00	0.26	3.32	3.21	2.83
Stollery - 03	2001	0.68	15	0.43	4	0.09	2.24	0.00	2.76	2.50
Stollery - 14	2001	0.58	20	0.14	4	0.13	1.13	0.00	2.96	2.00
Walker - 01	2002	0.41	25	0.87	4	0.37	2.01	5.28	0.00	2.63
Walker - 24	2002	0.36	17	0.07	3	0.04	1.46	0.00	3.14	2.92
Walker - 34	2002	0.35	29	0.05	3	0.14	0.96	0.00	3.94	2.25
Walstrom - 15	2001	0.35	19	0.43	4	0.54	0.40	0.00	2.98	2.56
Walstrom - 20	2001	0.30	23	0.35	4	0.45	0.85	0.00	0.00	3.83
Ziegler - 12	2002	0.37	10	0.42	3	0.05	2.50	17.85	0.00	3.63
Ziegler - 19	2002	0.31	16	0.06	3	0.08	2.08	0.00	3.44	2.88

Site	Year	WAREA	WET	WINTENSE	WTREND	WVOR	GRTYP	PASTSCR	PINTENSE	PMAXHGT
Ames - 24	2002	1.87	1	M	0.26	0.31	N	46.7	H	3.60
Ames - 26	2002	1.40	0	M	-0.01	0.09	N	46.7	H	3.60
Ames - 30	2002	1.26	0	M	0.17	0.21	N	46.7	H	3.60
B&E Lease - 46	2001	0.37	1	L	0.72		T	68.6	L	5.73
B&E Lease - 66	2001	0.88	0	L	0.37		T	68.6	L	5.73
Barritt Lease - 03	2002	0.33	0	H	-0.07	0.06	T	78.2	M	3.38
Barritt Lease - 14	2002	0.91	0	M	0.16	0.15	T	78.2	M	3.38
Basilian - 01	2002	0.46	1	L	0.12	0.34	T	84.0	L	6.13
Basilian - 38	2002	0.52	0	L	-0.08	0.41	T	84.0	L	6.13
Basilian - 75	2002	1.67	1	L	0.39	0.36	N	84.0	L	3.27
Basilian - 97	2002	0.85	0	M	0.42	0.23	T	84.0	M	2.66
Behnke - 12	2002	0.71	0	M	-0.09	0.32	T	79.2	M	2.00
Behnke - 16	2002	0.63	1	M	-0.40	0.28	T	79.2	M	2.00
Berger - 01	2002	1.40	1	H	0.50	0.13	T	59.4	H	1.40
Berger - 27	2002	0.24	0	M	0.48	0.65	T	59.4	H	1.40
Berger - 30	2002	0.58	1	H	0.88	0.12	T	59.4	H	1.40
Berger - 32	2002	0.56	0	M	0.85	0.12	T	59.4	H	1.40
Best - 04	2002	1.77	0	M	-0.36	0.33	T	55.8	M	1.53
Best - 10	2002	0.40	0	M	-0.14	0.25	T	55.8	M	1.53
Bilan - 16	2002	0.09	0	H	0.82	0.05	T	51.7	H	1.00
Bilan - 19	2002	1.26	1	H	-0.11	0.15	T	51.7	H	1.00
Bilan - 22	2002	0.17	0	H	-0.17	0.05	T	51.7	H	1.00
Bilan - 29	2002	1.54	0	H	-0.14	0.16	T	51.7	H	1.00
Bosma - 28	2001	1.55	1	H	0.46		T	27.4	M	1.35
Bosma - 30	2001	0.85	1	H	0.21		T	27.4	M	1.35
Brimacombe26 - 15	2002	0.61	0	H	-0.13	0.27	T	71.8	H	2.28
Brimacombe26 - 19	2002	0.64	0	H	-0.12	0.26	T	71.8	H	2.28
Brimacombe34 - 07	2002	0.59	0	H	-0.02	0.08	T	55.2	H	1.38
Brimacombe34 - 18	2002	0.78	0	H	-0.06	0.21	T	55.2	H	1.38
Brimacombe34 - 22	2002	1.60	1	H	-0.29	0.13	T	55.2	H	1.38
Brosinsky - 15	2001	1.03	1	M	-0.30		N	31.6	H	1.38
Brosinsky - 29	2001	0.45	0	H	0.36		N	31.6	H	1.38
Brownlee - 10	2001	0.71	1	M	1.01		T	53.3	M	3.45
Brownlee - 18	2001	0.28	0	M	0.93		T	53.3	M	3.45
Cha - 09	2001	2.52	1	L	-0.10		T	48.6	H	1.00
Cha - 14	2001	1.71	1	H	0.28		T	48.6	H	1.00
CJohnson - 12	2002	1.27	0	M	0.55	0.10	N	53.5	H	2.45
Cole&Rhymer - 03	2001	1.33	1	M	0.01		N	34.9	H	1.45

Site	Year	WAREA	WET	WINTENSE	WTREND	WVOR	GRTYP	PASTSCR	PINTENSE	PMAXHGT
Cole&Rhymer - 11	2001	0.58	1	M	-0.29		N	34.9	H	1.45
CollinsCrown - 10	2001	0.36	0	M	0.87		N	46.0	M	3.23
CollinsCrown - 20	2001	0.70	1	M	0.17		N	46.0	M	3.23
Cossey - 14	2002	1.20	1	H	0.08		N	22.2	H	1.12
Crown - 04	2002	2.37	0	H	0.37	0.26	N	63.1	M	5.15
Crown - 08	2002	0.49	0	H	0.68	0.13	N	63.1	M	5.15
Crown - 20	2002	1.81	1	M	0.19	0.53	N	63.1	M	5.15
Dahl - 35	2001	1.11	1	H	-0.07		T	24.8	H	0.73
Dahl - 51	2001	0.62	0	H	-0.24		T	24.8	H	0.73
Dawson - 01	2001	0.72	1	M	0.65		T	61.2	M	4.88
Dawson - 08	2001	1.68	1	M	0.59		T	61.2	M	4.88
DUC-Andrews - 03	2001	0.71	1	M	0.60		T	88.0	L	4.78
DUC-Andrews - 03	2002	0.71	1	L	0.02	0.52	T	94.4	L	5.47
DUC-Andrews - 07	2002	1.37	1	L	-0.13	0.82	T	94.4	L	5.47
DUC-Andrews - 36	2001	0.49	1	L	0.43		T	88.0	L	4.78
DUC-Beck - 15	2001	0.32	0	L	0.66		T	71.0	L	2.93
DUC-Beck - 15	2002	0.32	0	L	-0.08	0.41	N	63.3	L	4.23
DUC-Beck - 18	2001	2.04	1	L	0.74		T	71.0	L	2.93
DUC-Beck - 18	2002	2.04	0	L	1.10	0.51	N	63.3	L	4.23
DUC-Blaikie - 03	2001	0.95	1	L	0.89		N	76.2	L	5.10
DUC-Blaikie - 05	2001	0.35	1	L	0.49		N	76.2	L	5.10
DUC-Bluesky - 13	2001	0.22	1	M	0.25		N	47.6	M	4.75
DUC-Bluesky - 13	2002	0.22	0	M	1.76	0.12	N	55.4	M	2.22
DUC-Bluesky - 46	2001	1.49	1	M	0.66		N	47.6	M	4.75
DUC-Bluesky - 46	2002	1.49	1	M	0.44	0.14	N	55.4	M	2.22
DUC-Boyden - 02	2001	1.00	0	M	0.14		T	72.1	L	6.05
DUC-Boyden - 15	2001	0.75	0	M	0.55		T	72.1	L	6.05
DUC-Caine - 12	2002	2.16	0	L	0.28	0.13	T	93.4	M	4.52
DUC-Caine - 14	2002	0.49	0	L	0.71	0.11	T	93.4	M	4.52
DUC-Dochstader - 14	2002	1.29	0	L	-0.12	0.32	T	94.8	L	4.62
DUC-Hawthorne - 02	2001	1.58	1	L	1.12		T	80.0	L	4.85
DUC-Hawthorne - 02	2002	1.60	1	L	0.46	0.29	T	99.5	L	5.98
DUC-Hawthorne - 18	2001	2.68	1	L	0.56		T	80.0	L	4.85
DUC-Hawthorne - 18	2002	0.64	1	M	0.80	0.24	T	99.5	L	5.98
DUC-Johnson - 05	2002	1.13	1	L	1.52	0.29	T	85.4	L	4.10
DUC-Johnson - 22	2002	1.66	1	L	0.17	0.28	T	85.4	L	4.10
DUC-Johnson - 33	2002	0.29	0	L	0.39	0.42	T	85.4	L	4.10
DUC-Lawson - 09	2001	0.97	1	L	0.29		N	68.4	L	4.78

Site	Year	WAREA	WET	WINTENSE	WTREND	WVOR	GRTYP	PASTSCR	PINTENSE	PMAXHGT
DUC-Lawson - 09	2002	1.33	0	L	0.35	0.41	N		L	4.25
DUC-Lawson - 10	2001	0.98	1	L	0.86		N	68.4	L	4.78
DUC-Lawson - 10	2002	0.58	0	L	-0.30	0.36	N		L	4.25
DUC-Lyseng - 16	2001	0.56	0	L	1.21		T	84.7	L	4.00
DUC-Lyseng - 17	2001	0.12	0	L	3.17		T	84.7	L	4.00
DUC-Nixon - 20	2001	0.19	0	L	1.01		T	83.0	L	6.35
DUC-Nixon - 31	2001	2.20	1	L	1.03		T	83.0	L	6.35
DUC-Siemens - 03	2002	0.34	1	H	-0.24	0.09	T	74.8	M	4.22
DUC-Siemens - 15	2002	0.44	0	M	-0.14	0.27	T	74.8	M	4.22
DUC-Siemens - 27	2002	1.51	0	M	0.14	0.24	T	74.8	M	4.22
DUC-Stauffer - 06	2002	0.89	1	L	-0.16	0.42	T	69.8	L	4.82
DUC-Stauffer - 28	2002	2.31	1	L	-0.01	0.32	T	69.8	L	4.82
DUC-Stauffer - 31	2002	0.56	0	L	-0.05	0.30	T	69.8	L	4.82
DUC-Thompson - 22	2001	1.64	1	H	1.40		T	80.3	M	3.28
DUC-Thompson - 33	2001	1.24	1	L	1.00		T	80.3	M	3.28
DUC-Vanguard - 03	2002	0.12	0	L	0.36	0.31	T	79.7	M	4.18
DUC-Vanguard - 08	2002	0.22	0	L	0.44	0.12	T	79.7	M	4.18
DUC-Vanguard - 10	2002	0.14	0	L	0.13	0.30	T	79.7	M	4.18
DUC-Wik - 02	2001	0.16	0	L	0.88		T	75.1	M	3.83
DUC-Wik - 15	2001	0.44	0	L	0.36		T	75.1	M	3.83
DUC-Willy - 01	2002	0.87	0	M	0.47	0.01	N	42.0	H	2.90
DUC-Willy - 02	2002	0.84	0	L	0.00	0.21	N	42.0	H	2.90
DUC-Willy - 04	2002	1.50	1	M	0.76	0.07	N	42.0	H	2.90
Fankhanel - 21	2001	0.34	1	M	0.27		T	51.7	H	1.45
Fankhanel - 25	2001	1.67	1	H	0.16		T	51.7	H	1.45
Felt - 04	2002	0.37	0	H	0.04	0.09	N	39.1	H	1.07
Felt - 19	2002	0.43	0	M	0.04	0.20	N	39.1	H	1.07
Frerefarms - 34	2001	0.85	1	H	0.02		N	34.3	H	2.43
Frerefarms - 61	2001	1.22	1	H	-0.52		N	34.3	H	2.43
Gloria Lease - 02	2001	0.43	1	L	0.47		N	70.5	L	4.25
Gloria Lease - 12	2001	0.49	0	L	0.88		N	70.5	L	4.25
Hagstrom - 11	2002	0.84	0	L	0.79	0.30	T	85.3	L	4.95
Hagstrom - 31	2002	4.35	0	L	0.29	0.53	T	85.3	L	4.95
Hagstrom - 81	2002	1.92	0	L	0.09	0.32	T	85.3	L	4.95
Hilson Investments - 07	2001	2.24	1	H	0.09		T	34.6	H	1.37
Hilson Investments -11	2001	1.20	1	H	0.51		T	34.6	H	1.37
Hofstra - 18	2002	0.36	0	H	0.23	0.27	N	56.7	M	2.13
Hofstra - 27	2002	0.51	0	H	0.22	0.30	N	56.7	M	2.13

Site	Year	WAREA	WET	WINTENSE	WTREND	WVOR	GRTYP	PASTSCR	PINTENSE	PMAXHGT
Hofstra – 29	2002	0.91	0	M	0.58	0.20	N	56.7	M	2.13
Jensen - 04	2001	0.59	1	H	0.26		N	47.7	M	2.93
Jensen - 30	2001	0.91	0	M	0.79		N	47.7	M	2.93
Klassen - 02	2001	2.74	1	L	0.66		N	61.3	L	7.00
Klassen - 08	2001	7.49	1	L	0.68		N	61.3	L	7.00
Krause - 32	2001	1.35	0	H	-0.28		N	40.6	H	2.53
Krause - 54	2001	0.86	1	H	-0.21		N	40.6	H	2.53
Lakeview - 02	2001	0.82	1	M	0.87		T	60.2	M	2.96
Lazari - 07	2002	1.62	1	H	-0.32	0.07	N	21.5	L	1.98
Lazari - 08	2002	1.49	1	M	-0.24	0.26	N	21.5	L	1.98
MacNaughton - 06	2001	1.25	0	H	0.20		N	55.4	M	4.13
MacNaughton - 47	2001	1.91	1	H	0.59		N	55.4	M	4.13
Matson - 04	2002	0.46	0	M	0.35	0.17	T	66.0	H	1.90
Matson - 07	2002	0.33	0	H	-0.09	0.08	T	66.0	H	1.90
Matson - 20	2002	0.21	0	M	0.72	0.02	T	66.0	H	1.90
Mayowski - 02	2002	1.05	0	M	-0.23	0.26	T	69.1	M	3.07
Mayowski - 12	2002	2.01	0	H	-0.12	0.24	T	69.1	M	3.07
Mayowski - 15	2002	1.41	0	H	-0.11	0.31	T	69.1	M	3.07
McKinney - 05	2002	0.50	0	M	0.63	0.20	N	46.4	H	1.93
McKinney - 09	2002	0.40	0	H	1.02	0.17	N	46.4	H	1.93
McKinney - 28	2002	0.69	0	M	1.05	0.16	N	46.4	H	1.93
Miquelon - 07	2001	0.64	1	L	1.63		N	60.4	L	
Miquelon - 07	2002	0.91	0	L	0.79	0.47	N		L	5.94
Miquelon - 39	2001	0.50	1	L	0.69		N	60.4	L	
Miquelon - 39	2002	1.20	0	L	0.45	0.67	N		L	5.94
Montgomery - 03	2001	0.34	1	H	0.53		T	29.0	H	2.10
Montgomery - 25	2001	2.93	1	H	0.31		T	29.0	H	2.10
Moseson - 08	2001	0.97	1	H	1.05		T	62.7	H	2.00
Moseson - 11	2001	1.90	1	M	0.87		T	62.7	H	2.00
Neufeld - 32	2002	1.40	0	H	1.21	0.11	N	52.0	H	1.98
Neufeld - 37	2002	0.62	0	M	1.68	0.15	N	52.0	H	1.98
Neufeld - 38	2002	2.42	1	M	1.21	0.20	N	52.0	H	1.98
Ohman Lease - 02	2001	1.77	1	L	0.24		T	73.7	L	2.73
Ohman Lease - 30	2001	1.51	1	L	1.02		T	73.7	L	2.73
Peters - 21	2001	1.03	0	H	0.75		T	67.5	L	2.50
Peters - 28	2001	0.73	1	H	0.63		T	67.5	L	2.50
Plaister - 04	2001	0.72	1	L	0.27		N	43.5	L	3.83
Plaister - 08	2001	0.35	0	M	0.78		N	43.5	L	3.83

Site	Year	WAREA	WET	WINTENSE	WTREND	WVOR	GRTYP	PASTSCR	PINTENSE	PMAXHGT
Pyramid – 13	2002	0.23	0	H	1.06	0.36	N	28.4	H	3.30
Pyramid - 36	2002	3.92	1	H	0.03	0.11	N	28.4	H	3.30
SalmonNE - 14	2001	0.36	1	H	-0.35		N	42.7	L	4.65
SalmonNE - 26	2001	0.31	1	H	1.55		N	42.7	L	4.65
SalmonSW - 01	2002	0.56	0	L	0.25	0.19	N	56.3	L	7.38
SalmonSW - 06	2002	4.35	0	L	0.11	0.33	N	56.3	L	7.38
Sargeant - 36	2001	0.33	1	H	0.13		T	53.8	M	2.25
Sargeant - 66	2001	0.69	1	H	0.07		T	53.8	M	2.25
Schoff - 12	2001	0.43	1	H	1.14		N	68.7	M	4.47
Schoff - 19	2001	0.88	1	M	0.39		N	68.7	M	4.47
Shute - 13	2002	1.63	0	H	-0.02	0.08	N	29.3	M	2.02
Shute - 25	2002	0.91	0	H	0.07	0.10	N	29.3	M	2.02
Shute - 27	2002	0.96	0	H	-0.23	0.35	N	29.3	M	2.02
Stavne - 08	2001	0.67	0	M	1.19		T	40.6	H	1.65
Stavne - 27	2001	0.71	0	M	0.16		T	40.6	H	1.65
Stavne - 27	2002	0.71	0	M	-0.09	0.18	T		H	1.28
Stavne - 29	2002	1.15	0	M	0.07	0.27	T		H	1.28
Stavne - 31	2002	0.63	0	H	0.07	0.30	T		H	1.28
Steele -10	2001	1.52	1	M	-0.11		T	46.7	M	2.95
Steele -14	2001	0.37	1	M	0.45		T	46.7	M	2.95
Stollery - 03	2001	4.73	1	L	0.03		N	34.3	H	0.98
Stollery - 14	2001	1.08	1	M	0.02		N	34.3	H	0.98
Walker - 01	2002	2.34	1	M	0.37	0.23	N	25.4	H	1.47
Walker - 24	2002	1.82	1	M	0.29	0.14	N	25.4	H	1.47
Walker - 34	2002	0.37	1	M	0.60	0.30	N	25.4	H	1.47
Walstrom - 15	2001	0.79	0	H	0.42		N	48.3	H	2.74
Walstrom - 20	2001	0.78	1	H	0.22		N	48.3	H	2.74
Ziegler - 12	2002	8.74	1	H	0.26	0.37	N	39.0	M	2.32
Ziegler - 19	2002	0.75	0	H	0.07	0.31	N	39.0	M	2.32

Site	Year	PROPWET	PTREND	PVOR	WDDENSE	WETDENSE	GL1	GL2	GL3	GL4	NORTH
Ames - 24	2002	0.08	0.16	0.11	0.18	0.23	0.391	0.378	0.318	0.310	5829800
Ames - 26	2002	0.08	0.16	0.11	0.18	0.23	0.391	0.378	0.318	0.310	5829750
Ames - 30	2002	0.08	0.16	0.11	0.18	0.23	0.391	0.378	0.318	0.310	5829500
B&E Lease - 46	2001	0.17	1.68	0.92	0.03	0.26	0.616	0.395	0.282	0.216	5765000
B&E Lease - 66	2001	0.17	1.68	0.92	0.03	0.26	0.616	0.395	0.282	0.216	5764600
Barritt Lease - 03	2002	0.23	0.28	0.14	0.05	0.34	0.236	0.236	0.282	0.278	5810200
Barritt Lease - 14	2002	0.23	0.28	0.14	0.05	0.34	0.236	0.236	0.282	0.278	5810200
Basilian - 01	2002	0.01	0.05	0.82	0.09	0.33	0.133	0.258	0.288	0.269	5936400
Basilian - 38	2002	0.01	0.05	0.82	0.09	0.33	0.133	0.258	0.288	0.269	5936000
Basilian - 75	2002	0.01	0.05	0.84	0.09	0.33	0.133	0.258	0.288	0.269	5935200
Basilian - 97	2002	0.01	0.05	0.19	0.09	0.33	0.133	0.258	0.288	0.269	5935300
Behnke - 12	2002	0.10	0.01	0.11	0.10	0.40	0.340	0.297	0.290	0.277	5876000
Behnke - 16	2002	0.10	0.01	0.11	0.10	0.40	0.340	0.297	0.290	0.277	5876050
Berger - 01	2002	0.09	0.21	0.03	0.10	0.36	0.306	0.166	0.208	0.242	5878900
Berger - 27	2002	0.09	0.21	0.03	0.10	0.36	0.306	0.166	0.208	0.242	5878000
Berger - 30	2002	0.09	0.21	0.03	0.10	0.36	0.306	0.166	0.208	0.242	5878000
Berger - 32	2002	0.09	0.21	0.03	0.10	0.36	0.306	0.166	0.208	0.242	5877900
Best - 04	2002	0.00	0.03	0.00	0.05	0.17	0.313	0.324	0.321	0.294	5899800
Best - 10	2002	0.00	0.03	0.00	0.05	0.17	0.313	0.324	0.321	0.294	5899700
Bilan - 16	2002	0.20	0.00	0.03	0.17	0.29	0.371	0.297	0.335	0.333	5938400
Bilan - 19	2002	0.20	0.00	0.03	0.17	0.29	0.371	0.297	0.335	0.333	5938300
Bilan - 22	2002	0.20	0.00	0.03	0.17	0.29	0.371	0.297	0.335	0.333	5938300
Bilan - 29	2002	0.20	0.00	0.03	0.17	0.29	0.371	0.297	0.335	0.333	5938100
Bosma - 28	2001	0.13	0.08	0.08	0.01	0.18	0.610	0.441	0.397	0.385	5809200
Bosma - 30	2001	0.13	0.08	0.08	0.01	0.18	0.610	0.441	0.397	0.385	5808200
Brimacombe26 - 15	2002	0.22	-0.08	0.18	0.11	0.22	0.071	0.134	0.153	0.166	5825250
Brimacombe26 - 19	2002	0.22	-0.08	0.18	0.11	0.22	0.071	0.134	0.153	0.166	5825150
Brimacombe34 - 07	2002	0.07	0.00	0.00	0.04	0.17	0.468	0.420	0.380	0.361	5827100
Brimacombe34 - 18	2002	0.07	0.00	0.00	0.04	0.17	0.468	0.420	0.380	0.361	5827000
Brimacombe34 - 22	2002	0.07	0.00	0.00	0.04	0.17	0.468	0.420	0.380	0.361	5826800
Brosinsky - 15	2001	0.34	0.03	0.02	0.10	0.51	0.440	0.356	0.369	0.343	5827700
Brosinsky - 29	2001	0.34	0.03	0.02	0.10	0.51	0.440	0.356	0.369	0.343	5827300
Brownlee - 10	2001	0.17	0.23	0.24	0.10	0.20	0.403	0.258	0.221	0.192	5916500
Brownlee - 18	2001	0.17	0.23	0.24	0.10	0.20	0.403	0.258	0.221	0.192	5916600
Cha - 09	2001	0.13	0.47	0.09	0.01	0.21	0.246	0.246	0.234	0.224	5874900
Cha - 14	2001	0.13	0.47	0.09	0.01	0.21	0.246	0.246	0.234	0.224	5875100
CJohnson - 12	2002	0.05	0.26	0.12	0.02	0.26	0.140	0.156	0.139	0.135	5869050
Cole&Rhymer - 03	2001	0.09	0.13	0.11	0.03	0.18	0.445	0.303	0.255	0.234	5864000

Site	Year	PROPWET	PTREND	PVOR	WDDENSE	WETDENSE	GL1	GL2	GL3	GL4	NORTH
Cole&Rhymer - 11	2001	0.09	0.13	0.11	0.03	0.18	0.445	0.303	0.255	0.234	5864050
CollinsCrown - 10	2001	0.24	0.43	0.17	0.31	0.30	0.464	0.517	0.535	0.533	5766900
CollinsCrown - 20	2001	0.24	0.43	0.17	0.31	0.30	0.464	0.517	0.535	0.533	5766600
Cossey - 14	2002	0.09	0.00	0.00	0.02	0.22	0.808	0.752	0.702	0.704	5941250
Crown - 04	2002	0.04	0.89	0.23	0.56	0.20	0.309	0.243	0.245	0.235	5801800
Crown - 08	2002	0.04	0.89	0.23	0.56	0.20	0.309	0.243	0.245	0.235	5801800
Crown - 20	2002	0.04	0.89	0.23	0.56	0.20	0.309	0.243	0.245	0.235	5801350
Dahl - 35	2001	0.07	0.06	0.01	0.04	0.24	0.672	0.530	0.440	0.428	5774100
Dahl - 51	2001	0.07	0.06	0.01	0.04	0.24	0.672	0.530	0.440	0.428	5773800
Dawson - 01	2001	0.18	1.13	0.49	0.02	0.45	0.306	0.270	0.218	0.260	5842100
Dawson - 08	2001	0.18	1.13	0.49	0.02	0.45	0.306	0.270	0.218	0.260	5841900
DUC-Andrews - 03	2001	0.24	1.71	1.04	0.12	0.33	0.374	0.344	0.319	0.296	5831950
DUC-Andrews - 03	2002	0.16	0.30	0.58	0.12	0.33	0.374	0.344	0.319	0.296	5831950
DUC-Andrews - 07	2002	0.16	0.30	0.58	0.12	0.33	0.374	0.344	0.319	0.296	5832000
DUC-Andrews - 36	2001	0.24	1.71	1.04	0.12	0.33	0.374	0.344	0.319	0.296	5831900
DUC-Beck - 15	2001	0.30	0.47	0.62	0.22	0.32	0.413	0.378	0.367	0.375	5880400
DUC-Beck - 15	2002	0.27	0.31	0.70	0.22	0.32	0.413	0.378	0.367	0.375	5880400
DUC-Beck - 18	2001	0.30	0.47	0.62	0.22	0.32	0.413	0.378	0.367	0.375	5880200
DUC-Beck - 18	2002	0.27	0.31	0.70	0.22	0.32	0.413	0.378	0.367	0.375	5880200
DUC-Blaikie - 03	2001	0.14	1.00	1.11	0.25	0.23	0.705	0.669	0.599	0.562	5779300
DUC-Blaikie - 05	2001	0.14	1.00	1.11	0.25	0.23	0.705	0.669	0.599	0.562	5779150
DUC-Bluesky - 13	2001	0.18	-0.55	1.01	0.12	0.21	0.500	0.333	0.260	0.263	5874300
DUC-Bluesky - 13	2002	0.13	0.30	0.14	0.12	0.21	0.500	0.333	0.260	0.263	5874300
DUC-Bluesky - 46	2001	0.18	-0.55	1.01	0.12	0.21	0.500	0.333	0.260	0.263	5873800
DUC-Bluesky - 46	2002	0.13	0.30	0.14	0.12	0.21	0.500	0.333	0.260	0.263	5873800
DUC-Boyden - 02	2001	0.01	2.03	1.55	0.15	0.15	0.364	0.386	0.414	0.402	5771850
DUC-Boyden - 15	2001	0.01	2.03	1.55	0.15	0.15	0.364	0.386	0.414	0.402	5771250
DUC-Caine - 12	2002	0.05	0.18	0.17	0.32	0.22	0.347	0.321	0.303	0.304	5818250
DUC-Caine - 14	2002	0.05	0.18	0.17	0.32	0.22	0.347	0.321	0.303	0.304	5818350
DUC-Dochstader - 14	2002	0.05	0.30	0.68	0.02	0.50	0.434	0.289	0.234	0.202	5935900
DUC-Hawthorne - 02	2001	0.23	1.59	0.56	0.27	0.31	0.320	0.341	0.350	0.316	5795500
DUC-Hawthorne - 02	2002	0.23	0.28	0.47	0.27	0.31	0.320	0.341	0.350	0.316	5795500
DUC-Hawthorne - 18	2001	0.23	1.59	0.56	0.27	0.31	0.320	0.341	0.350	0.316	5795000
DUC-Hawthorne - 18	2002	0.23	0.28	0.47	0.27	0.31	0.320	0.341	0.350	0.316	5795000
DUC-Johnson - 05	2002	0.16	0.46	0.69	0.03	0.24	0.447	0.440	0.425	0.330	5873950
DUC-Johnson - 22	2002	0.16	0.46	0.69	0.03	0.24	0.447	0.440	0.425	0.330	5873650
DUC-Johnson - 33	2002	0.16	0.46	0.69	0.03	0.24	0.447	0.440	0.425	0.330	5873500
DUC-Lawson - 09	2001	0.15	0.55	0.73	0.37	0.19	0.358	0.272	0.308	0.334	5812900

Site	Year	PROPWET	PTREND	PVOR	WDDENSE	WETDENSE	GL1	GL2	GL3	GL4	NORTH
DUC-Lawson - 09	2002	0.15		0.94	0.37	0.19	0.358	0.272	0.308	0.334	5812900
DUC-Lawson - 10	2001	0.15	0.55	0.73	0.37	0.19	0.358	0.272	0.308	0.334	5813100
DUC-Lawson - 10	2002	0.15		0.94	0.37	0.19	0.358	0.272	0.308	0.334	5813100
DUC-Lyseng - 16	2001	0.39	0.61	0.73	0.21	0.47	0.351	0.292	0.287	0.299	5890850
DUC-Lyseng - 17	2001	0.39	0.61	0.73	0.21	0.47	0.351	0.292	0.287	0.299	5890800
DUC-Nixon - 20	2001	0.20	1.29	0.64	0.09	0.26	0.453	0.355	0.323	0.292	5821400
DUC-Nixon - 31	2001	0.20	1.29	0.64	0.09	0.26	0.453	0.355	0.323	0.292	5821200
DUC-Siemens - 03	2002	0.12	-0.01	0.35	0.19	0.22	0.116	0.241	0.274	0.276	5835300
DUC-Siemens - 15	2002	0.12	-0.01	0.35	0.19	0.22	0.116	0.241	0.274	0.276	5835300
DUC-Siemens - 27	2002	0.12	-0.01	0.35	0.19	0.22	0.116	0.241	0.274	0.276	5835300
DUC-Stauffer - 06	2002	0.10	0.55	0.62	0.06	0.28	0.288	0.278	0.270	0.271	5838700
DUC-Stauffer - 28	2002	0.10	0.55	0.62	0.06	0.28	0.288	0.278	0.270	0.271	5838300
DUC-Stauffer - 31	2002	0.10	0.55	0.62	0.06	0.28	0.288	0.278	0.270	0.271	5838100
DUC-Thompson - 22	2001	0.13	1.31	0.33	0.08	0.42	0.133	0.102	0.107	0.129	5826400
DUC-Thompson - 33	2001	0.13	1.31	0.33	0.08	0.42	0.133	0.102	0.107	0.129	5826000
DUC-Vanguard - 03	2002	0.35	0.13	0.43	0.05	0.38	0.190	0.248	0.251	0.271	5892000
DUC-Vanguard - 08	2002	0.35	0.13	0.43	0.05	0.38	0.190	0.248	0.251	0.271	5891750
DUC-Vanguard - 10	2002	0.35	0.13	0.43	0.05	0.38	0.190	0.248	0.251	0.271	5891700
DUC-Wik - 02	2001	0.09	0.41	0.59	0.03	0.17	0.197	0.465	0.478	0.428	5769000
DUC-Wik - 15	2001	0.09	0.41	0.59	0.03	0.17	0.197	0.465	0.478	0.428	5768700
DUC-Willy - 01	2002	0.02	0.13	0.10	0.11	0.22	0.370	0.339	0.295	0.245	5816700
DUC-Willy - 02	2002	0.02	0.13	0.10	0.11	0.22	0.370	0.339	0.295	0.245	5816700
DUC-Willy - 04	2002	0.02	0.13	0.10	0.11	0.22	0.370	0.339	0.295	0.245	5816750
Fankhanel - 21	2001	0.10	0.39	0.01	0.03	0.42	0.157	0.196	0.246	0.263	5834100
Fankhanel - 25	2001	0.10	0.39	0.01	0.03	0.42	0.157	0.196	0.246	0.263	5833900
Felt - 04	2002	0.09	0.09	0.02	0.35	0.17	0.045	0.062	0.065	0.079	5828300
Felt - 19	2002	0.09	0.09	0.02	0.35	0.17	0.045	0.062	0.065	0.079	5828200
Frerefarms - 34	2001	0.26	0.48	0.08	0.17	0.26	0.645	0.551	0.531	0.499	5770650
Frerefarms - 61	2001	0.26	0.48	0.08	0.17	0.26	0.645	0.551	0.531	0.499	5770250
Gloria Lease - 02	2001	0.07	1.48	0.86	0.55	0.13	0.547	0.429	0.372	0.343	5770050
Gloria Lease - 12	2001	0.07	1.48	0.86	0.55	0.13	0.547	0.429	0.372	0.343	5769800
Hagstrom - 11	2002	0.12	0.35	0.62	0.05	0.57	0.802	0.435	0.361	0.345	5886000
Hagstrom - 31	2002	0.12	0.35	0.62	0.05	0.57	0.802	0.435	0.361	0.345	5885600
Hagstrom - 81	2002	0.12	0.35	0.62	0.05	0.57	0.802	0.435	0.361	0.345	5884650
Hilson Investments - 07	2001	0.09	0.13	0.02	0.03	0.28	0.589	0.405	0.385	0.376	5872600
Hilson Investments -11	2001	0.09	0.13	0.02	0.03	0.28	0.589	0.405	0.385	0.376	5872700
Hofstra - 18	2002	0.02	0.39	0.16	0.11	0.24	0.781	0.488	0.420	0.447	5889200
Hofstra - 27	2002	0.02	0.39	0.16	0.11	0.24	0.781	0.488	0.420	0.447	5889000

Site	Year	PROPWET	PTREND	PVOR	WDDENSE	WETDENSE	GL1	GL2	GL3	GL4	NORTH
Hofstra - 29	2002	0.02	0.39	0.16	0.11	0.24	0.781	0.488	0.420	0.447	5889000
Jensen - 04	2001	0.09	0.24	0.24	0.15	0.16	0.156	0.194	0.184	0.190	5821700
Jensen - 30	2001	0.09	0.24	0.24	0.15	0.16	0.156	0.194	0.184	0.190	5821500
Klassen - 02	2001	0.20	1.38	0.92	0.26	0.40	0.233	0.194	0.195	0.167	5851900
Klassen - 08	2001	0.20	1.38	0.92	0.26	0.40	0.233	0.194	0.195	0.167	5851500
Krause - 32	2001	0.01	0.38	0.14	0.35	0.12	0.699	0.420	0.382	0.382	5770000
Krause - 54	2001	0.01	0.38	0.14	0.35	0.12	0.699	0.420	0.382	0.382	5769900
Lakeview - 02	2001	0.11	0.76	0.29	0.36	0.30	0.133	0.212	0.199	0.195	5898400
Lazari - 07	2002	0.06	-0.01	0.09	0.50	0.13	0.382	0.386	0.393	0.372	5893900
Lazari - 08	2002	0.06	-0.01	0.09	0.50	0.13	0.382	0.386	0.393	0.372	5893800
MacNaughton - 06	2001	0.08	0.69	0.38	0.43	0.15	0.326	0.300	0.275	0.230	5820350
MacNaughton - 47	2001	0.08	0.69	0.38	0.43	0.15	0.326	0.300	0.275	0.230	5819900
Matson - 04	2002	0.11	0.03	0.11	0.29	0.23	0.291	0.302	0.269	0.261	5893700
Matson - 07	2002	0.11	0.03	0.11	0.29	0.23	0.291	0.302	0.269	0.261	5893600
Matson - 20	2002	0.11	0.03	0.11	0.29	0.23	0.291	0.302	0.269	0.261	5893350
Mayowski - 02	2002	0.03	-0.02	0.18	0.00	0.16	0.522	0.359	0.312	0.302	5943500
Mayowski - 12	2002	0.03	-0.02	0.18	0.00	0.16	0.522	0.359	0.312	0.302	5943300
Mayowski - 15	2002	0.03	-0.02	0.18	0.00	0.16	0.522	0.359	0.312	0.302	5943000
McKinney - 05	2002	0.02	0.15	0.03	0.13	0.25	0.520	0.321	0.312	0.332	5891300
McKinney - 09	2002	0.02	0.15	0.03	0.13	0.25	0.520	0.321	0.312	0.332	5891300
McKinney - 28	2002	0.02	0.15	0.03	0.13	0.25	0.520	0.321	0.312	0.332	5891000
Miquelon - 07	2001	0.29	0.00	2.50	0.10	0.46	0.333	0.278	0.188	0.175	5904500
Miquelon - 07	2002	0.29		0.87	0.10	0.46	0.333	0.278	0.188	0.175	5904500
Miquelon - 39	2001	0.29	0.00	2.50	0.10	0.46	0.333	0.278	0.188	0.175	5904600
Miquelon - 39	2002	0.29		0.87	0.10	0.46	0.333	0.278	0.188	0.175	5904600
Montgomery - 03	2001	0.11	-0.01	0.02	0.02	0.30	0.374	0.317	0.350	0.387	5833300
Montgomery - 25	2001	0.11	-0.01	0.02	0.02	0.30	0.374	0.317	0.350	0.387	5833000
Moseson - 08	2001	0.12	0.32	0.05	0.19	0.24	0.340	0.227	0.176	0.153	5854450
Moseson - 11	2001	0.12	0.32	0.05	0.19	0.24	0.340	0.227	0.176	0.153	5854300
Neufeld - 32	2002	0.15	0.35	0.12	0.10	0.40	0.546	0.512	0.493	0.499	5888000
Neufeld - 37	2002	0.15	0.35	0.12	0.10	0.40	0.546	0.512	0.493	0.499	5888100
Neufeld - 38	2002	0.15	0.35	0.12	0.10	0.40	0.546	0.512	0.493	0.499	5888000
Ohman Lease - 02	2001	0.13	2.18	0.90	0.09	0.21	0.083	0.155	0.192	0.228	5877200
Ohman Lease - 30	2001	0.13	2.18	0.90	0.09	0.21	0.083	0.155	0.192	0.228	5876900
Peters - 21	2001	0.13	0.61	0.06	0.06	0.23	0.369	0.343	0.343	0.355	5807900
Peters - 28	2001	0.13	0.61	0.06	0.06	0.23	0.369	0.343	0.343	0.355	5807600
Plaister - 04	2001	0.09	0.34	0.33	0.37	0.20	0.063	0.075	0.089	0.135	5821950
Plaister - 08	2001	0.09	0.34	0.33	0.37	0.20	0.063	0.075	0.089	0.135	5821750

Site	Year	PROPWET	PTREND	PVOR	WDDENSE	WETDENSE	GL1	GL2	GL3	GL4	NORTH
Pyramid – 13	2002	0.03	0.18	0.04	0.42	0.06	0.126	0.190	0.227	0.240	5808300
Pyramid - 36	2002	0.03	0.18	0.04	0.42	0.06	0.126	0.190	0.227	0.240	5807300
SalmonNE - 14	2001	0.26	0.53	0.19	0.21	0.37	0.368	0.315	0.346	0.330	5822500
SalmonNE - 26	2001	0.26	0.53	0.19	0.21	0.37	0.368	0.315	0.346	0.330	5822500
SalmonSW - 01	2002	0.00	0.01	0.13	0.17	0.22	0.298	0.369	0.306	0.307	5824500
SalmonSW - 06	2002	1.00	0.01	0.13	0.17	0.22	0.298	0.369	0.306	0.307	5824200
Sargeant - 36	2001	0.02	0.16	0.13	0.30	0.15	0.083	0.121	0.173	0.228	5818600
Sargeant - 66	2001	0.02	0.16	0.13	0.30	0.15	0.083	0.121	0.173	0.228	5815250
Schoff - 12	2001	0.23	1.54	0.26	0.11	0.32	0.212	0.276	0.282	0.276	5831300
Schoff - 19	2001	0.23	1.54	0.26	0.11	0.32	0.212	0.276	0.282	0.276	5831350
Shute - 13	2002	0.00	0.18	0.10	0.18	0.17	0.334	0.365	0.434	0.444	5886750
Shute - 25	2002	0.00	0.18	0.10	0.18	0.17	0.334	0.365	0.434	0.444	5886350
Shute - 27	2002	0.00	0.18	0.10	0.18	0.17	0.334	0.365	0.434	0.444	5886250
Stavne - 08	2001	0.06	0.26	0.11	0.18	0.22	0.150	0.133	0.146	0.145	5903300
Stavne - 27	2001	0.06	0.26	0.11	0.18	0.22	0.150	0.133	0.146	0.145	5903000
Stavne - 27	2002	0.06		0.03	0.18	0.22	0.150	0.133	0.146	0.145	5903000
Stavne - 29	2002	0.06		0.03	0.18	0.22	0.150	0.133	0.146	0.145	5902800
Stavne - 31	2002	0.06		0.03	0.18	0.22	0.150	0.133	0.146	0.145	5903200
Steele -10	2001	0.09	0.48	0.22	0.11	0.15	0.759	0.558	0.500	0.455	5784500
Steele -14	2001	0.09	0.48	0.22	0.11	0.15	0.759	0.558	0.500	0.455	5784662
Stollery - 03	2001	0.18	0.11	0.03	0.24	0.20	0.183	0.165	0.169	0.149	5900900
Stollery - 14	2001	0.18	0.11	0.03	0.24	0.20	0.183	0.165	0.169	0.149	5900500
Walker - 01	2002	0.16	0.03	0.06	0.29	0.26	0.172	0.199	0.218	0.215	5897500
Walker - 24	2002	0.16	0.03	0.06	0.29	0.26	0.172	0.199	0.218	0.215	5897450
Walker - 34	2002	0.16	0.03	0.06	0.29	0.26	0.172	0.199	0.218	0.215	5897200
Walstrom - 15	2001	0.03	0.27	0.07	0.41	0.11	0.250	0.245	0.256	0.294	5815650
Walstrom - 20	2001	0.03	0.27	0.07	0.41	0.11	0.250	0.245	0.256	0.294	5815650
Ziegler - 12	2002	0.33	0.09	0.09	0.00	0.44	0.928	0.773	0.797	0.782	5937900
Ziegler - 19	2002	0.33	0.09	0.09	0.00	0.44	0.928	0.773	0.797	0.782	5937300

Site	Year	PC1	PC2	PC3	PC4	WO1	WO2	WO3	WO4
Ames - 24	2002	0.947	0.834	0.815	0.780	0.342	0.312	0.358	0.332
Ames - 26	2002	0.947	0.834	0.815	0.780	0.342	0.312	0.358	0.332
Ames - 30	2002	0.947	0.834	0.815	0.780	0.342	0.312	0.358	0.332
B&E Lease - 46	2001	0.677	0.521	0.419	0.373	0.059	0.050	0.045	0.043
B&E Lease - 66	2001	0.677	0.521	0.419	0.373	0.059	0.050	0.045	0.043
Barritt Lease - 03	2002	0.818	0.879	0.874	0.824	0.257	0.234	0.261	0.247
Barritt Lease - 14	2002	0.818	0.879	0.874	0.824	0.257	0.234	0.261	0.247
Basilian - 01	2002	0.424	0.376	0.391	0.367	0.101	0.056	0.067	0.065
Basilian - 38	2002	0.424	0.376	0.391	0.367	0.101	0.056	0.067	0.065
Basilian - 75	2002	0.424	0.376	0.391	0.367	0.101	0.056	0.067	0.065
Basilian - 97	2002	0.424	0.376	0.391	0.367	0.101	0.056	0.067	0.065
Behnke - 12	2002	0.759	0.634	0.638	0.591	0.002	0.020	0.044	0.056
Behnke - 16	2002	0.759	0.634	0.638	0.591	0.002	0.020	0.044	0.056
Berger - 01	2002	0.619	0.469	0.475	0.528	0.015	0.037	0.024	0.027
Berger - 27	2002	0.619	0.469	0.475	0.528	0.015	0.037	0.024	0.027
Berger - 30	2002	0.619	0.469	0.475	0.528	0.015	0.037	0.024	0.027
Berger - 32	2002	0.619	0.469	0.475	0.528	0.015	0.037	0.024	0.027
Best - 04	2002	0.976	0.895	0.882	0.851	0.193	0.269	0.193	0.163
Best - 10	2002	0.976	0.895	0.882	0.851	0.193	0.269	0.193	0.163
Bilan - 16	2002	0.773	0.740	0.789	0.802	0.190	0.237	0.254	0.300
Bilan - 19	2002	0.773	0.740	0.789	0.802	0.190	0.237	0.254	0.300
Bilan - 22	2002	0.773	0.740	0.789	0.802	0.190	0.237	0.254	0.300
Bilan - 29	2002	0.773	0.740	0.789	0.802	0.190	0.237	0.254	0.300
Bosma - 28	2001	0.792	0.835	0.768	0.723	0.039	0.147	0.185	0.196
Bosma - 30	2001	0.792	0.835	0.768	0.723	0.039	0.147	0.185	0.196
Brimacombe26 - 15	2002	0.386	0.513	0.533	0.581	0.231	0.190	0.184	0.179
Brimacombe26 - 19	2002	0.386	0.513	0.533	0.581	0.231	0.190	0.184	0.179
Brimacombe34 - 07	2002	0.844	0.724	0.749	0.744	0.255	0.176	0.190	0.204
Brimacombe34 - 18	2002	0.844	0.724	0.749	0.744	0.255	0.176	0.190	0.204
Brimacombe34 - 22	2002	0.844	0.724	0.749	0.744	0.255	0.176	0.190	0.204
Brosinsky - 15	2001	0.893	0.889	0.858	0.817	0.295	0.418	0.404	0.371
Brosinsky - 29	2001	0.893	0.889	0.858	0.817	0.295	0.418	0.404	0.371
Brownlee - 10	2001	0.989	0.907	0.878	0.815	0.585	0.543	0.514	0.480
Brownlee - 18	2001	0.989	0.907	0.878	0.815	0.585	0.543	0.514	0.480
Cha - 09	2001	0.662	0.566	0.465	0.483	0.083	0.133	0.101	0.101
Cha - 14	2001	0.662	0.566	0.465	0.483	0.083	0.133	0.101	0.101
CJohnson - 12	2002	0.431	0.441	0.372	0.391	0.049	0.066	0.059	0.091
Cole&Rhymer - 03	2001	0.862	0.733	0.610	0.543	0.278	0.291	0.266	0.223

Site	Year	PC1	PC2	PC3	PC4	WO1	WO2	WO3	WO4
Cole&Rhymer - 11	2001	0.862	0.733	0.610	0.543	0.278	0.291	0.266	0.223
CollinsCrown - 10	2001	0.823	0.824	0.811	0.813	0.239	0.156	0.125	0.105
CollinsCrown - 20	2001	0.823	0.824	0.811	0.813	0.239	0.156	0.125	0.105
Cossey - 14	2002	0.966	0.846	0.794	0.788	0.158	0.091	0.065	0.054
Crown - 04	2002	0.981	0.763	0.694	0.678	0.612	0.286	0.224	0.237
Crown - 08	2002	0.981	0.763	0.694	0.678	0.612	0.286	0.224	0.237
Crown - 20	2002	0.981	0.763	0.694	0.678	0.612	0.286	0.224	0.237
Dahl - 35	2001	0.888	0.845	0.725	0.706	0.063	0.073	0.066	0.065
Dahl - 51	2001	0.888	0.845	0.725	0.706	0.063	0.073	0.066	0.065
Dawson - 01	2001	0.715	0.650	0.504	0.557	0.221	0.159	0.137	0.145
Dawson - 08	2001	0.715	0.650	0.504	0.557	0.221	0.159	0.137	0.145
DUC-Andrews - 03	2001	0.865	0.928	0.885	0.806	0.468	0.471	0.413	0.352
DUC-Andrews - 03	2002	0.865	0.928	0.885	0.806	0.468	0.471	0.413	0.352
DUC-Andrews - 07	2002	0.865	0.928	0.885	0.806	0.468	0.471	0.413	0.352
DUC-Andrews - 36	2001	0.865	0.928	0.885	0.806	0.468	0.471	0.413	0.352
DUC-Beck - 15	2001	0.873	0.661	0.583	0.576	0.325	0.173	0.128	0.107
DUC-Beck - 15	2002	0.873	0.661	0.583	0.576	0.325	0.173	0.128	0.107
DUC-Beck - 18	2001	0.873	0.661	0.583	0.576	0.325	0.173	0.128	0.107
DUC-Beck - 18	2002	0.873	0.661	0.583	0.576	0.325	0.173	0.128	0.107
DUC-Blaikie - 03	2001	0.978	0.872	0.830	0.783	0.124	0.087	0.076	0.073
DUC-Blaikie - 05	2001	0.978	0.872	0.830	0.783	0.124	0.087	0.076	0.073
DUC-Bluesky - 13	2001	0.722	0.537	0.492	0.481	0.105	0.107	0.110	0.107
DUC-Bluesky - 13	2002	0.722	0.537	0.492	0.481	0.105	0.107	0.110	0.107
DUC-Bluesky - 46	2001	0.722	0.537	0.492	0.481	0.105	0.107	0.110	0.107
DUC-Bluesky - 46	2002	0.722	0.537	0.492	0.481	0.105	0.107	0.110	0.107
DUC-Boyden - 02	2001	0.524	0.576	0.625	0.628	0.058	0.056	0.039	0.042
DUC-Boyden - 15	2001	0.524	0.576	0.625	0.628	0.058	0.056	0.039	0.042
DUC-Caine - 12	2002	0.915	0.926	0.865	0.825	0.460	0.472	0.425	0.399
DUC-Caine - 14	2002	0.915	0.926	0.865	0.825	0.460	0.472	0.425	0.399
DUC-Dochstader - 14	2002	0.631	0.408	0.357	0.309	0.167	0.096	0.091	0.074
DUC-Hawthorne - 02	2001	0.504	0.614	0.650	0.663	0.024	0.032	0.039	0.063
DUC-Hawthorne - 02	2002	0.504	0.614	0.650	0.663	0.024	0.032	0.039	0.063
DUC-Hawthorne - 18	2001	0.504	0.614	0.650	0.663	0.024	0.032	0.039	0.063
DUC-Hawthorne - 18	2002	0.504	0.614	0.650	0.663	0.024	0.032	0.039	0.063
DUC-Johnson - 05	2002	0.681	0.745	0.782	0.705	0.139	0.132	0.127	0.142
DUC-Johnson - 22	2002	0.681	0.745	0.782	0.705	0.139	0.132	0.127	0.142
DUC-Johnson - 33	2002	0.681	0.745	0.782	0.705	0.139	0.132	0.127	0.142
DUC-Lawson - 09	2001	0.987	0.874	0.816	0.783	0.558	0.507	0.381	0.321

Site	Year	PC1	PC2	PC3	PC4	WO1	WO2	WO3	WO4
DUC-Lawson - 09	2002	0.987	0.874	0.816	0.783	0.558	0.507	0.381	0.321
DUC-Lawson - 10	2001	0.987	0.874	0.816	0.783	0.558	0.507	0.381	0.321
DUC-Lawson - 10	2002	0.987	0.874	0.816	0.783	0.558	0.507	0.381	0.321
DUC-Lyseng - 16	2001	0.671	0.651	0.670	0.693	0.183	0.169	0.199	0.189
DUC-Lyseng - 17	2001	0.671	0.651	0.670	0.693	0.183	0.169	0.199	0.189
DUC-Nixon - 20	2001	0.862	0.770	0.684	0.628	0.387	0.333	0.286	0.253
DUC-Nixon - 31	2001	0.862	0.770	0.684	0.628	0.387	0.333	0.286	0.253
DUC-Siemens - 03	2002	0.475	0.592	0.622	0.634	0.222	0.186	0.173	0.183
DUC-Siemens - 15	2002	0.475	0.592	0.622	0.634	0.222	0.186	0.173	0.183
DUC-Siemens - 27	2002	0.475	0.592	0.622	0.634	0.222	0.186	0.173	0.183
DUC-Stauffer - 06	2002	0.723	0.637	0.636	0.632	0.271	0.163	0.164	0.168
DUC-Stauffer - 28	2002	0.723	0.637	0.636	0.632	0.271	0.163	0.164	0.168
DUC-Stauffer - 31	2002	0.723	0.637	0.636	0.632	0.271	0.163	0.164	0.168
DUC-Thompson - 22	2001	0.700	0.626	0.574	0.587	0.357	0.253	0.204	0.194
DUC-Thompson - 33	2001	0.700	0.626	0.574	0.587	0.357	0.253	0.204	0.194
DUC-Vanguard - 03	2002	0.695	0.644	0.648	0.684	0.260	0.190	0.185	0.191
DUC-Vanguard - 08	2002	0.695	0.644	0.648	0.684	0.260	0.190	0.185	0.191
DUC-Vanguard - 10	2002	0.695	0.644	0.648	0.684	0.260	0.190	0.185	0.191
DUC-Wik - 02	2001	0.348	0.631	0.646	0.587	0.090	0.108	0.098	0.088
DUC-Wik - 15	2001	0.348	0.631	0.646	0.587	0.090	0.108	0.098	0.088
DUC-Willy - 01	2002	0.470	0.571	0.564	0.522	0.089	0.111	0.117	0.096
DUC-Willy - 02	2002	0.470	0.571	0.564	0.522	0.089	0.111	0.117	0.096
DUC-Willy - 04	2002	0.470	0.571	0.564	0.522	0.089	0.111	0.117	0.096
Fankhanel - 21	2001	0.780	0.716	0.665	0.630	0.332	0.291	0.253	0.225
Fankhanel - 25	2001	0.780	0.716	0.665	0.630	0.332	0.291	0.253	0.225
Felt - 04	2002	0.918	0.741	0.663	0.649	0.201	0.181	0.161	0.161
Felt - 19	2002	0.918	0.741	0.663	0.649	0.201	0.181	0.161	0.161
Frerefarms - 34	2001	0.957	0.843	0.777	0.737	0.063	0.056	0.062	0.054
Frerefarms - 61	2001	0.957	0.843	0.777	0.737	0.063	0.056	0.062	0.054
Gloria Lease - 02	2001	0.752	0.630	0.535	0.537	0.164	0.113	0.081	0.075
Gloria Lease - 12	2001	0.752	0.630	0.535	0.537	0.164	0.113	0.081	0.075
Hagstrom - 11	2002	0.915	0.654	0.598	0.576	0.000	0.001	0.013	0.028
Hagstrom - 31	2002	0.915	0.654	0.598	0.576	0.000	0.001	0.013	0.028
Hagstrom - 81	2002	0.915	0.654	0.598	0.576	0.000	0.001	0.013	0.028
Hilson Investments - 07	2001	0.953	0.794	0.769	0.753	0.215	0.252	0.213	0.167
Hilson Investments -11	2001	0.953	0.794	0.769	0.753	0.215	0.252	0.213	0.167
Hofstra - 18	2002	0.885	0.834	0.783	0.798	0.040	0.145	0.137	0.103
Hofstra - 27	2002	0.885	0.834	0.783	0.798	0.040	0.145	0.137	0.103

Site	Year	PC1	PC2	PC3	PC4	WO1	WO2	WO3	WO4
Hofstra – 29	2002	0.885	0.834	0.783	0.798	0.040	0.145	0.137	0.103
Jensen - 04	2001	0.919	0.861	0.808	0.730	0.110	0.119	0.107	0.106
Jensen - 30	2001	0.919	0.861	0.808	0.730	0.110	0.119	0.107	0.106
Klassen - 02	2001	0.626	0.673	0.597	0.508	0.217	0.347	0.298	0.227
Klassen - 08	2001	0.626	0.673	0.597	0.508	0.217	0.347	0.298	0.227
Krause - 32	2001	0.788	0.660	0.615	0.574	0.052	0.114	0.101	0.080
Krause - 54	2001	0.788	0.660	0.615	0.574	0.052	0.114	0.101	0.080
Lakeview - 02	2001	0.921	0.837	0.854	0.808	0.546	0.489	0.496	0.439
Lazari - 07	2002	0.664	0.568	0.591	0.555	0.091	0.066	0.090	0.085
Lazari - 08	2002	0.664	0.568	0.591	0.555	0.091	0.066	0.090	0.085
MacNaughton - 06	2001	0.782	0.497	0.510	0.520	0.440	0.176	0.183	0.177
MacNaughton - 47	2001	0.782	0.497	0.510	0.520	0.440	0.176	0.183	0.177
Matson - 04	2002	0.865	0.759	0.734	0.707	0.491	0.342	0.278	0.247
Matson - 07	2002	0.865	0.759	0.734	0.707	0.491	0.342	0.278	0.247
Matson - 20	2002	0.865	0.759	0.734	0.707	0.491	0.342	0.278	0.247
Mayowski - 02	2002	0.687	0.593	0.574	0.612	0.032	0.103	0.084	0.135
Mayowski - 12	2002	0.687	0.593	0.574	0.612	0.032	0.103	0.084	0.135
Mayowski - 15	2002	0.687	0.593	0.574	0.612	0.032	0.103	0.084	0.135
McKinney - 05	2002	0.915	0.838	0.836	0.800	0.055	0.145	0.176	0.168
McKinney - 09	2002	0.915	0.838	0.836	0.800	0.055	0.145	0.176	0.168
McKinney - 28	2002	0.915	0.838	0.836	0.800	0.055	0.145	0.176	0.168
Miquelon - 07	2001	0.931	0.955	0.913	0.885	0.598	0.677	0.718	0.681
Miquelon - 07	2002	0.931	0.955	0.913	0.885	0.598	0.677	0.718	0.681
Miquelon - 39	2001	0.931	0.955	0.913	0.885	0.598	0.677	0.718	0.681
Miquelon - 39	2002	0.931	0.955	0.913	0.885	0.598	0.677	0.718	0.681
Montgomery - 03	2001	0.720	0.651	0.639	0.647	0.213	0.171	0.161	0.156
Montgomery - 25	2001	0.720	0.651	0.639	0.647	0.213	0.171	0.161	0.156
Moseson - 08	2001	0.638	0.504	0.463	0.417	0.160	0.221	0.234	0.192
Moseson - 11	2001	0.638	0.504	0.463	0.417	0.160	0.221	0.234	0.192
Neufeld - 32	2002	0.705	0.747	0.726	0.730	0.038	0.037	0.021	0.023
Neufeld - 37	2002	0.705	0.747	0.726	0.730	0.038	0.037	0.021	0.023
Neufeld - 38	2002	0.705	0.747	0.726	0.730	0.038	0.037	0.021	0.023
Ohman Lease - 02	2001	0.434	0.485	0.494	0.548	0.079	0.038	0.025	0.049
Ohman Lease - 30	2001	0.434	0.485	0.494	0.548	0.079	0.038	0.025	0.049
Peters - 21	2001	0.749	0.714	0.671	0.621	0.190	0.179	0.158	0.125
Peters - 28	2001	0.749	0.714	0.671	0.621	0.190	0.179	0.158	0.125
Plaister - 04	2001	0.768	0.768	0.727	0.700	0.100	0.107	0.126	0.121
Plaister - 08	2001	0.768	0.768	0.727	0.700	0.100	0.107	0.126	0.121

Site	Year	PC1	PC2	PC3	PC4	WO1	WO2	WO3	WO4
Pyramid - 13	2002	0.951	0.884	0.830	0.729	0.555	0.427	0.364	0.319
Pyramid - 36	2002	0.951	0.884	0.830	0.729	0.555	0.427	0.364	0.319
SalmonNE - 14	2001	0.879	0.815	0.855	0.830	0.344	0.366	0.354	0.343
SalmonNE - 26	2001	0.879	0.815	0.855	0.830	0.344	0.366	0.354	0.343
SalmonSW - 01	2002	0.876	0.895	0.826	0.773	0.424	0.368	0.394	0.352
SalmonSW - 06	2002	0.876	0.895	0.826	0.773	0.424	0.368	0.394	0.352
Sargeant - 36	2001	0.935	0.799	0.762	0.755	0.019	0.076	0.146	0.150
Sargeant - 66	2001	0.935	0.799	0.762	0.755	0.019	0.076	0.146	0.150
Schoff - 12	2001	0.598	0.687	0.748	0.786	0.261	0.315	0.336	0.332
Schoff - 19	2001	0.598	0.687	0.748	0.786	0.261	0.315	0.336	0.332
Shute - 13	2002	0.645	0.620	0.644	0.611	0.270	0.163	0.151	0.119
Shute - 25	2002	0.645	0.620	0.644	0.611	0.270	0.163	0.151	0.119
Shute - 27	2002	0.645	0.620	0.644	0.611	0.270	0.163	0.151	0.119
Stavne - 08	2001	0.999	0.929	0.876	0.849	0.511	0.644	0.570	0.527
Stavne - 27	2001	0.999	0.929	0.876	0.849	0.511	0.644	0.570	0.527
Stavne - 27	2002	0.999	0.929	0.876	0.849	0.511	0.644	0.570	0.527
Stavne - 29	2002	0.999	0.929	0.876	0.849	0.511	0.644	0.570	0.527
Stavne - 31	2002	0.999	0.929	0.876	0.849	0.511	0.644	0.570	0.527
Steele -10	2001	0.999	0.937	0.914	0.870	0.042	0.078	0.096	0.100
Steele -14	2001	0.999	0.937	0.914	0.870	0.042	0.078	0.096	0.100
Stollery - 03	2001	0.927	0.712	0.715	0.786	0.526	0.395	0.427	0.487
Stollery - 14	2001	0.927	0.712	0.715	0.786	0.526	0.395	0.427	0.487
Walker - 01	2002	0.907	0.788	0.777	0.786	0.532	0.449	0.394	0.419
Walker - 24	2002	0.907	0.788	0.777	0.786	0.532	0.449	0.394	0.419
Walker - 34	2002	0.907	0.788	0.777	0.786	0.532	0.449	0.394	0.419
Walstrom - 15	2001	0.480	0.539	0.626	0.698	0.215	0.237	0.308	0.324
Walstrom - 20	2001	0.480	0.539	0.626	0.698	0.215	0.237	0.308	0.324
Ziegler - 12	2002	0.975	0.879	0.876	0.873	0.041	0.090	0.069	0.079
Ziegler - 19	2002	0.975	0.879	0.876	0.873	0.041	0.090	0.069	0.079

Appendix 2: Common and scientific names of bird species detected during point counts in 2001 and 2002.

Common Name	Scientific Name	2001			2002		
		CB[1]	PB[2]	CAS[3]	CB[1]	PB[2]	CAS[3]
Alder Flycatcher	*Empidonax alnorum*		2	8	1	2	14
American Avocet	*Recurvirostra americana*	2		1	1		
American Coot	*Fulica americana*	6	6	11	11	2	6
American Crow	*Corvus brachyrhynchos*			7			11
American Goldfinch	*Carduelis tristis*			7			11
American Robin	*Turdus migratorius*		5	18		3	16
American Wigeon	*Anas americana*		2	6			5
Barn Swallow	*Hirundo rustica*						2
Black Tern	*Chlidonias niger*	3	1	3	2	1	7
Black-billed Magpie	*Pica pica*			5		2	6
Black-capped Chickadee	*Parus atricapillus*			16			7
Blue Jay	*Cyanocitta cristata*						1
Blue-winged Teal	*Anas discors*	5	14	41	8	26	21
Brewer's Blackbird	*Euphagus cyanocephalus*						2
Brown-headed Cowbird	*Molothrus ater*			2			6
Bufflehead	*Bucephala albeola*			8		1	7
Canada Goose	*Branta canadensis*						5
Canvasback	*Aythya valisineria*	1		2			1
Cedar Waxwing	*Bombycilla cedrorum*			4			4
Chipping Sparrow	*Spizella passerina*						1
Cinnemon Teal	*Anas cyanoptera*			1			5
Clay-colored Sparrow	*Spizella pallida*	2	36	25	27	35	25
Common Goldeneye	*Bucephala clangula*			2			1
Common Grackle	*Quiscalus quiscula*				1		1
Common Raven	*Corvus corax*			1			
Common Snipe	*Gallinago gallinago*	1		7	8		12
Common Yellowthroat	*Geothlypis trichas*		1	13	1	2	6
Downy Woodpecker	*Picoides pubescens*			1			2
Eastern Kingbird	*Tyrannus tyrannus*			9			8
Eastern Phoebe	*Sayornis phoebe*						1
Gadwall	*Anas strepera*	1	2	19	1	5	26
Gray Catbird	*Dumetella carolinensis*			1			6
Great Blue Heron	*Ardea herodias*			2			1
Green-winged Teal	*Anas crecca*			13		1	11
Horned Grebe	*Podiceps auritus*	2	3	1	1	1	4
House Sparrow	*Passer domesticus*						2
House Wren	*Troglodytes aedon*			21		6	17
Killdeer	*Charadrius vociferus*		5	13	2	1	9
Least Flycatcher	*Empidonax minimus*		7	15		11	23
LeConte's Sparrow	*Ammodramus leconteii*		6	23	1	6	16
Lesser Scaup	*Aythya affinis*	2	1	1	4	1	9
Lesser Yellowlegs	*Tringa flavipes*			5			7
Lincoln's Sparrow	*Melospiza lincolnii*				5	1	6
Magnolia Warbler	*Dendroica magnolia*						1
Mallard	*Anas platyrynchos*	6	7	24	8	5	27

Appendix 2: cont.

Common Name	Scientific Name	2001			2002		
		CB[1]	PB[2]	CAS[3]	CB[1]	PB[2]	CAS[3]
Marsh Wren	*Cistothorus palustris*		1	5			
Northen Harrier	*Circus cyaneus*			1			
Northern Oriole	*Icterus galbula*		2	9			1
Northern Pintail	*Anas acuta*			1			2
Northern Shoveler	*Anas clypeata*	2		18	8	3	14
Pied-billed Grebe	*Podilymbus podiceps*			2			2
Pine Siskin	*Carduelis pinus*						
Redhead	*Aythya americana*			1	3	1	3
Red-tailed Hawk	*Buteo jamaicensis*			5			4
Red-winged Blackbird	*Agelaius phoeniceus*	28	9	2	41	15	18
Ruddy Duck	*Oxyura jamaicensis*	6	2	9	1		2
Ruffed Grouse	*Bonasa umbellus*			1			
Savannah Sparrow	*Passerculus sandwichensis*	7	2	19	25	28	23
Sharp-tailed Sparrow	*Ammodramus nelsoni*			1		3	15
Short Billed Dowitcher	*Limnodromus griseus*						1
Solitary Sandpiper	*Tringa solitaria*						1
Song Sparrow	*Melospiza melodia*		1	19	8	9	27
Sora	*Porzana carolina*	1	3	11	2	2	18
Spotted Sandpiper	*Actitis macularia*		1	6	4		3
Spragues Pipit	*Anthus spragueii*					1	11
Swamp Sparrow	*Melospiza georgiana*					1	2
Tree Swallow	*Tachycineta bicolor*		1	16		2	14
Vesper Sparrow	*Pooecetes gramineus*		2	2	1	4	18
Warbling Vireo	*Vireo gilvus*						3
Western Meadowlark	*Sturnella neglecta*					1	5
Western Wood-peewee	*Contopus sordidulus*						1
White-throated Sparrow	*Zonotrichia albicollis*			4			2
Willet	*Catoptrophorus semipamatus*			2			1
Willow Flycatcher	*Empidonax traliilii*						1
Wilson's Phalarope	*Phalaropus tricolor*			3			5
Yellow Warbler	*Dendroica petachia*		11	29		8	3
Yellow-bellied Sapsucker	*Sphyrapicus varius*						2
Yellow-headed Blackbird	*Xanthocephlaus xanthocephalus*	8		5	4		1
Yellow-shafted Flicker	*Colaptes auratus*			1			4

[1] Confirmed breeding has occurred, indicated by direct observation of a nest. The number of wetlands at which at least one nest of each species was detected is indicated.
[2] Species is probably breeding at wetland, indicated by repeated observation of species during consecutive point counts at study sites. The number of wetlands at which each species was observed twice is indicated.
[3] Species is probably not breeding at wetland (casual occupants). Species was observed only once during consecutive point counts at study sites. The number of wetlands at which each species was detected once is indicated.

Appendix 3: Spearman correlation coefficients of covariates used to model breeding species richness, nest density and nest survival of wetland birds in the Aspen Parkland of Alberta during 2001 and 2002.

	YEAR	NORTH	PCLASS	COVER	CP	BBNESTS	CAI	MAXHGT	WTREND	WVOR	NPLANT	BARE	SEARCH	WAREA
YEAR	1.00	0.40	-0.24	-0.17	0.07	0.10	-0.05	-0.12	-0.27	.	0.29	-0.02	0.39	0.00
NORTH		1.00	-0.18	-0.25	0.15	0.19	0.03	-0.05	-0.05	0.06	0.02	-0.15	0.13	0.01
PCLASS			1.00	0.23	-0.13	0.24	-0.05	0.29	0.04	-0.02	0.10	0.02	0.08	0.26
COVER				1.00	-0.04	0.09	-0.02	0.03	0.09	0.05	0.24	0.10	-0.09	0.04
CP					1.00	-0.01	0.74	-0.39	-0.28	-0.38	0.02	0.37	0.03	0.02
BBNESTS						1.00	0.01	0.30	-0.15	0.06	0.06	-0.07	0.05	0.04
CAI							1.00	-0.39	-0.45	-0.37	-0.16	0.36	0.02	-0.03
MAXHGT								1.00	-0.23	0.59	0.06	-0.27	0.04	0.12
WTREND									1.00	-0.01	0.04	-0.06	-0.23	-0.12
WVOR										1.00	0.13	-0.43	0.13	0.16
NPLANT											1.00	0.04	0.20	0.12
BARE												1.00	-0.10	0.04
SEARCH													1.00	0.71
WAREA														1.00
LNWAREA														
OWTR														
WET														
PCTOPEN														
DISTASP														
COVSHB														
COVTRE														
DISTWET														
PVOR														
PMAXHGT														
PASTSCR														
PAREA														
WETDENSE														
PROPWET														

Appendix 3: cont:

	LNWAREA	OWTR	WET	PCTOPEN	DISTASP	COVSHB	COVTRE	DISTWET	PVOR	PMAXHGT	PASTSCR	PAREA	WETDENSE	PROPWET
YEAR	0.00	-0.19	-0.43	-0.23	0.09	0.15	-0.07	-0.04	-0.19	-0.07	0.12	0.00	0.07	-0.23
NORTH	0.01	-0.21	-0.18	-0.27	0.08	-0.07	-0.06	-0.21	-0.14	-0.34	-0.03	-0.24	0.29	0.02
PCLASS	0.26	0.35	0.26	0.28	-0.06	0.00	0.11	-0.03	0.02	0.04	0.12	-0.13	0.09	0.04
COVER	0.04	0.46	0.25	0.52	-0.01	0.00	0.11	0.03	-0.01	0.08	0.00	-0.10	0.05	0.01
CP	0.02	-0.03	-0.03	0.00	-0.10	0.15	0.09	0.03	-0.74	-0.65	-0.70	0.08	-0.33	-0.30
BBNESTS	0.04	0.13	0.11	0.16	0.02	-0.02	0.03	-0.06	0.01	-0.09	0.05	-0.16	0.16	0.00
CAI	-0.03	-0.10	-0.05	-0.05	-0.06	0.08	0.11	0.14	-0.68	-0.62	-0.57	0.08	-0.31	-0.31
MAXHGT	0.12	1.17	0.16	0.11	-0.05	-0.12	0.02	0.03	0.43	0.33	0.38	-0.07	0.14	0.20
WTREND	-0.12	0.00	0.05	0.06	0.12	-0.09	-0.12	-0.09	0.30	0.24	0.21	-0.11	0.27	0.24
WVOR	0.16	0.20	0.07	0.11	0.11	-0.16	-0.06	-0.07	0.52	0.49	0.37	0.02	0.24	0.16
NPLANT	0.12	0.12	-0.05	0.05	-0.05	0.13	0.04	-0.08	-0.03	0.06	0.05	-0.14	0.14	-0.07
BARE	0.04	0.18	0.29	0.22	0.01	0.00	0.02	0.03	-0.35	-0.27	-0.31	0.10	-0.12	-0.08
SEARCH	0.71	0.22	0.03	-0.15	-0.09	0.22	0.07	-0.04	-0.08	0.00	-0.02	0.04	-0.01	-0.17
WAREA	1.00	0.58	0.34	0.16	-0.15	0.16	0.17	-0.08	-0.04	0.02	-0.09	-0.04	-0.03	-0.06
LNWAREA	1.00	0.58	0.34	0.16	-0.15	0.16	0.17	-0.08	-0.04	0.02	-0.09	-0.04	-0.03	-0.06
OWTR		1.00	0.45	0.85	-0.11	0.10	0.16	-0.07	0.02	0.11	-0.07	-0.07	0.00	0.02
WET			1.00	0.36	-0.14	-0.03	0.08	-0.05	0.04	0.01	-0.12	-0.03	0.08	0.22
PCTOPEN				1.00	-0.09	0.03	0.13	-0.03	0.04	0.09	-0.07	-0.09	-0.05	0.00
DISTASP					1.00	0.38	-0.57	0.00	0.01	0.01	0.12	-0.07	0.06	-0.08
COVSHB						1.00	0.34	-0.12	-0.06	0.03	-0.26	0.07	-0.17	-0.10
COVTRE							1.00	0.07	-0.06	-0.08	-0.19	-0.05	-0.12	-0.10
DISTWET								1.00	0.00	-0.05	-0.03	-0.08	-0.20	-0.12
PVOR									1.00	0.84	0.68	0.07	0.15	0.30
PMAXHGT										1.00	0.63	0.12	0.16	0.20
PASTSCR											1.00	0.05	0.33	0.20
PAREA												1.00	-0.16	0.13
WETDENSE													1.00	0.56
PROPWET														1.00

Appendix 3: cont:

	WDDENSE	PC1	PC2	PC3	PC4	GL1	GL2	GL3	GL4	WO1	WO2	WO3	WO4
YEAR	-0.03	-0.02	-0.03	0.04	0.06	-0.04	0.00	0.03	0.03	-0.03	-0.06	-0.06	-0.03
NORTH	-0.24	0.05	-0.01	0.04	0.12	-0.06	-0.18	-0.20	-0.19	0.06	0.12	0.13	0.15
PCLASS	-0.08	-0.17	-0.14	-0.15	-0.17	0.03	0.04	0.03	0.01	-0.18	-0.16	-0.14	-0.15
COVER	-0.03	-0.01	0.00	0.00	-0.03	0.05	0.02	-0.01	0.00	-0.07	-0.02	0.00	-0.02
CP	0.05	0.21	0.08	0.07	0.12	0.02	-0.08	-0.06	-0.01	-0.07	0.02	0.04	0.07
BBNESTS	-0.24	-0.07	-0.04	-0.06	-0.05	0.09	0.06	0.02	0.02	-0.18	-0.18	-0.14	-0.13
CAI	-0.06	0.14	0.06	0.09	0.15	0.08	0.04	0.12	0.17	-0.15	-0.05	-0.04	-0.02
MAXHGT	-0.08	-0.02	-0.01	-0.07	-0.12	-0.05	0.05	0.00	-0.05	0.09	0.03	-0.01	-0.01
WTREND	0.09	-0.07	-0.01	-0.02	-0.04	0.00	-0.06	-0.12	-0.11	0.02	0.00	-0.01	-0.02
WVOR	-0.21	0.16	0.11	0.05	0.00	0.06	0.08	0.04	0.03	0.07	-0.02	-0.04	-0.04
NPLANT	0.05	-0.03	0.03	0.00	-0.01	-0.04	-0.15	-0.06	-0.04	0.02	0.07	0.08	0.07
BARE	0.01	0.05	0.00	0.00	0.04	0.09	0.04	0.08	0.11	-0.09	-0.02	0.00	0.01
SEARCH	-0.09	0.02	-0.05	-0.07	-0.07	0.09	0.08	0.05	0.01	-0.04	-0.07	-0.07	-0.05
WAREA	-0.06	-0.01	-0.09	-0.14	-0.15	0.09	0.08	0.05	0.02	-0.05	-0.07	-0.08	-0.08
LNWAREA	-0.06	-0.01	-0.09	-0.14	-0.15	0.09	0.08	0.05	0.02	-0.05	-0.07	-0.08	-0.08
OWTR	-0.09	0.04	-0.01	-0.06	-0.10	0.22	0.18	0.11	0.09	-0.12	-0.10	-0.09	-0.11
WET	-0.01	-0.03	-0.04	-0.05	-0.06	0.01	-0.04	-0.03	-0.06	0.00	-0.02	0.00	0.00
PCTOPEN	-0.04	0.02	-0.01	-0.05	-0.09	0.22	0.18	0.12	0.12	-0.12	-0.10	-0.09	-0.12
DISTASP	-0.44	-0.15	-0.13	-0.11	-0.13	0.06	0.07	0.02	-0.02	-0.14	-0.11	-0.12	-0.11
COVSHB	0.37	0.14	0.14	0.17	0.16	0.09	0.07	0.06	0.03	0.15	0.14	0.15	0.17
COVTRE	0.40	0.09	0.07	0.02	0.02	-0.09	-0.09	-0.04	-0.01	0.12	0.11	0.09	0.06
DISTWET	0.07	0.05	-0.04	-0.06	-0.11	0.08	0.10	0.16	0.17	-0.02	-0.09	-0.11	-0.13
PVOR	0.10	-0.19	-0.13	-0.16	-0.21	-0.01	0.06	-0.02	-0.06	0.07	-0.09	-0.11	-0.11
PMAXHGT	0.15	-0.14	-0.07	-0.08	-0.15	-0.01	0.09	0.03	-0.01	0.13	-0.02	-0.04	-0.03
PAST5CR	-0.11	-0.34	-0.24	-0.20	-0.21	-0.13	-0.05	-0.05	-0.06	-0.04	-0.12	-0.14	-0.12
PAREA	0.12	0.19	0.03	0.01	0.03	-0.06	-0.13	-0.06	-0.05	0.08	0.03	0.01	0.06
WETDENSE	-0.34	-0.10	0.03	0.02	0.07	0.06	0.01	0.02	0.02	-0.03	-0.03	-0.03	-0.04
PROPWET	-0.09	0.02	0.15	0.17	0.20	0.07	0.03	0.01	0.01	0.20	0.19	0.17	0.19

Appendix 3: cont:

	WDDENSE	PC1	PC2	PC3	PC4	GL1	GL2	GL3	GL4	WO1	WO2	WO3	WO4
WDDENSE	1.00	0.21	0.12	0.15	0.13	-0.23	-0.22	-0.14	-0.10	0.31	0.25	0.25	0.23
PC1		1.00	0.84	0.73	0.68	0.23	0.07	0.02	0.05	0.43	0.47	0.46	0.43
PC2			1.00	0.94	0.87	0.17	0.13	0.12	0.14	0.44	0.56	0.57	0.54
PC3				1.00	0.96	0.11	0.12	0.17	0.18	0.42	0.55	0.58	0.57
PC4					1.00	0.08	0.07	0.13	0.17	0.39	0.53	0.57	0.57
GL1						1.00	0.86	0.74	0.70	-0.33	-0.29	-0.28	-0.30
GL2							1.00	0.92	0.85	-0.33	-0.36	-0.36	-0.39
GL3								1.00	0.96	-0.34	-0.35	-0.36	-0.39
GL4									1.00	-0.33	-0.33	-0.34	-0.36
WO1										1.00	0.90	0.85	0.83
WO2											1.00	0.98	0.95
WO3												1.00	0.98
WO4													1.00

Appendix 4: Breeding Species Richness (BSR) models

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Wetland *a priori*[e]				
$BSR_{LNWAREA+YEAR+PCLASS+MAXHGT}$	6	-256.29	0.0	0.3098
$BSR_{LNWAREA+YEAR+PCLASS}$	5	-254.93	1.4	0.1569
$BSR_{LNWAREA+YEAR+PCLASS+MAXHGT+OWTR}$	7	-254.39	1.9	0.1198
$BSR_{LNWAREA+YEAR+PCLASS+MAXHUT+MAXHUT^2}$	7	-254.15	2.1	0.1059
$BSR_{LNWAREA+YEAR+PCLASS+COVER}$	7	-254.14	2.2	0.1055
$BSR_{LNWAREA+YEAR+PCLASS+CAI}$	6	-253.66	2.6	0.0831
$BSR_{LNWAREA+YEAR+PCLASS+PBARE}$	6	-252.90	3.4	0.0566
$BSR_{LNWAREA+YEAR+PCLASS+WINTENSE}$	7	-251.63	4.7	0.0300
$BSR_{LNWAREA+YEAR+PCLASS+CAI+CAI^2}$	7	-251.62	4.7	0.0300
$BSR_{LNWAREA+YEAR}$	4	-246.40	9.9	0.0022
$BSR_{LNWAREA+PCLASS}$	4	-238.61	17.7	<0.0001
$BSR_{LNWAREA+MAXHUT}$	4	-238.44	17.9	<0.0001
$BSR_{LNWAREA+MAXHAGT+MAXHGT^2}$	5	-236.54	19.7	<0.0001
$BSR_{LNWAREA(NULL)}$	3	-235.98	20.3	<0.0001
$BSR_{LNWAREA+DISTASP}$	4	-235.83	20.5	<0.0001
$BSR_{LNWAREA+HPLANT}$	4	-235.76	20.5	<0.0001
$BSR_{LNWAREA+COVER}$	5	-235.56	20.7	<0.0001
$BSR_{LNWAREA+COVSHB}$	4	-235.40	20.9	<0.0001
$BSR_{LNWAREA+SQRTDISTASP}$	4	-235.08	21.2	<0.0001
$BSR_{LNWAREA+PBARE}$	4	-234.90	21.4	<0.0001
$BSR_{LNWAREA+CAI}$	4	-234.89	21.4	<0.0001
$BSR_{LNWAREA+DISTWET}$	4	-234.82	21.5	<0.0001
$BSR_{LNWAREA+SQRTDISTWET}$	4	-234.31	22.0	<0.0001
$BSR_{LNWAREA+COVTRE}$	4	-233.91	22.4	<0.0001
$BSR_{LNWAREA+CAI+CAI^2}$	5	-232.92	23.4	<0.0001
$BSR_{LNWAREA+WINTENSE}$	5	-232.86	23.4	<0.0001

Appendix 4: cont:

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Pasture *a priori*[e]				
BSR_{PVOR}	3	-207.72	0.0	0.1240
$BSR_{PINTENSE}$	4	-207.63	0.1	0.1189
BSR_{NULL}	2	-206.91	0.8	0.0830
$BSR_{WETDENSE}$	3	-206.60	1.1	0.0711
$BSR_{WETDENSE+PVOR}$	4	-206.49	1.2	0.0671
BSR_{CP}	3	-206.37	1.3	0.0634
$BSR_{WETDENSE+PINTENSE}$	5	-206.27	1.4	0.0603
$BSR_{GRTYPE+PINTENSE}$	5	-206.00	1.7	0.0526
$BSR_{PVOR+PVOR^2}$	4	-205.75	2.0	0.0463
$BSR_{WETDENSE+WDDENSE}$	4	-205.52	2.2	0.0413
$BSR_{WETDENSE+GRTYPE}$	4	-205.24	2.5	0.0360
$BSR_{WETDENSE+CP}$	4	-205.24	2.5	0.0359
BSR_{GRTYPE}	3	-205.24	2.5	0.0359
$BSR_{WETDENSE+PVOR+GRTYPE}$	5	-204.98	2.7	0.0315
$BSR_{WETDENSE+PINTENSE+GRTYPE}$	6	-204.84	2.9	0.0295
$BSR_{WETDENSE+PVOR+PVOR^2}$	5	-204.49	3.2	0.0247
$BSR_{WETDENSE+PVOR+CP}$	5	-204.38	3.3	0.0234
$BSR_{WETDENSE+PINTENSE+CP}$	6	-204.21	3.5	0.0214
$BSR_{GRTYPE+PINTENSE+GRTYPE*PINTENSE}$	7	-203.46	4.3	0.0147
$BSR_{WETDENSE+PVOR+GRTYPE+PVOR*GRTYPE}$	6	-202.88	4.8	0.0111
$BSR_{WETDENSE+PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	8	-202.22	5.5	0.0080

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Landscape Effects[e]				
BSR_{NORTH}	3	-209.65	0.0	0.2550
BSR_{GL1}	3	-209.60	0.1	0.2484
BSR_{GL2}	3	-207.26	2.4	0.0770
BSR_{NULL}	2	-206.91	2.7	0.0648
BSR_{WO1}	3	-206.53	3.1	0.0534
BSR_{GL3}	3	-205.88	3.8	0.0386
BSR_{WO2}	3	-205.87	3.8	0.0385
BSR_{PC2}	3	-205.83	3.8	0.0377
BSR_{PC3}	3	-205.74	3.9	0.0360
BSR_{PC4}	3	-205.58	4.1	0.0333
BSR_{GL4}	3	-205.52	4.1	0.0322
BSR_{WO3}	3	-205.48	4.2	0.0316
BSR_{WO4}	3	-205.22	4.4	0.0277
BSR_{PC1}	3	-205.08	4.6	0.0259

Appendix 4: cont:

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Exploratory Multi-Level[e]				
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+GL1}$	7	-266.37	0.0	0.1340
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+CP}$	7	-266.19	0.2	0.1222
$BSR_{LNWAREA+YEAR+PCLASS+PVOR}$	6	-265.37	1.0	0.0809
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+MAXHGT+GL1}$	8	-264.49	1.9	0.0523
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+NORTH}$	7	-264.38	2.0	0.0495
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+GL2}$	7	-264.30	2.1	0.0475
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+WDDENSE}$	7	-264.04	2.3	0.0418
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+COVSHB}$	7	-264.02	2.4	0.0412
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+SQRTDISTASP}$	7	-263.98	2.4	0.0404
$BSR_{LNWAREA+YEAR+PCLASS+OWTR+PVOR}$	7	-263.76	2.6	0.0362
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+DISTASP}$	7	-263.72	2.7	0.0356
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+GRTYPE}$	7	-263.70	2.7	0.0351
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+COVER}$	8	-263.65	2.7	0.0343
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+DISTWET}$	7	-263.61	2.8	0.0336
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+MAXHGT}$	7	-263.53	2.8	0.0323
$BSR_{LNWAREA+YEAR+PCLASS+NPLANT+PVOR}$	7	-263.36	3.0	0.0297
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+SQRTDISTWET}$	7	-263.35	3.0	0.0296
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+COVTRE}$	7	-263.33	3.0	0.0293
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+WETDENSE}$	7	-263.22	3.2	0.0277
$BSR_{LNWAREA+YEAR+PCLASS+DISTASP+WDDENSE+PVOR}$	8	-263.15	3.2	0.0267
$BSR_{LNWAREA+YEAR+PCLASS+NPLANT+PVOR+NORTH}$	8	-262.24	4.1	0.0169
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+PINTENSE}$	8	-261.81	4.6	0.0137
$BSR_{LNWAREA+YEAR+PCLASS+MAXHGT+GL1}$	7	-257.56	8.8	0.0016
$BSR_{LNWAREA+YEAR+PCLASS+MAXHGT+NORTH+GL1}$	8	-256.71	9.7	0.0011
$BSR_{LNWAREA+YEAR+PCLASS+MAXHGT}$	6	-256.29	10.1	0.0009
$BSR_{LNWAREA+YEAR+PCLASS+OWTR+MAXHGT+GL1}$	8	-255.65	10.7	0.0006
$BSR_{LNWAREA+YEAR+PCLASS+NPLANT+MAXHGT+GL1}$	8	-255.56	10.8	0.0006
$BSR_{LNWAREA+YEAR+PCLASS+MAXHGT+NORTH}$	7	-255.50	10.9	0.0006
$BSR_{LNWAREA+YEAR+PCLASS+PINTENSE}$	7	-255.45	10.9	0.0006
$BSR_{LNWAREA+YEAR+PCLASS+CAI+MAXHGT+GL1}$	8	-255.44	10.9	0.0006
$BSR_{LNWAREA+YEAR+PCLASS+CAI+GL1}$	7	-255.26	11.1	0.0005
$BSR_{LNWAREA+YEAR+PCLASS+OWTR+MAXHGT+NORTH+GL1}$	9	-255.11	11.3	0.0005
$BSR_{LNWAREA+YEAR+PCLASS}$	5	-254.93	11.4	0.0004
$BSR_{LNWAREA+YEAR+PCLASS+OWTR+MAXHGT}$	7	-254.39	12.0	0.0003
$BSR_{LNWAREA+YEAR+PCLASS+OWTR+GL1}$	7	-254.28	12.1	0.0003
$BSR_{LNWAREA+YEAR+PCLASS+NPLANT+GL1}$	7	-254.06	12.3	0.0003
$BSR_{LNWAREA+YEAR+PCLASS+OWTR+MAXHGT+NORTH}$	8	-253.90	12.5	0.0003
$BSR_{LNWAREA+YEAR+PCLASS+OWTR}$	6	-253.03	13.3	0.0002
$BSR_{LNWAREA+YEAR+PCLASS+OWTR+NPLANT}$	7	-251.00	15.4	0.0001
$BSR_{LNWAREA+YEAR}$	4	-246.40	20.0	<0.0001
$BSR_{LNWAREA+PCLASS}$	4	-238.61	27.8	<0.0001
$BSR_{LNWAREA}$	3	-235.98	30.4	<0.0001
BSR_{PCLASS}	3	-215.94	50.4	<0.0001
BSR_{YEAR}	3	-215.64	50.7	<0.0001
BSR_{NULL}	2	-206.91	59.5	<0.0001

Appendix 4: cont:

Model	k[a]	AIC_c[b]	ΔAIC_c[c]
Substituted Variables[f]			
$BSR_{LNWAREA+YEAR+PCLASS+PVOR+GL1}$	7	-234.22	0.0
$BSR_{LNWAREA+YEAR+PCLASS+PMAXHGT+GL1}$	7	-229.36	4.9
$BSR_{LNWAREA+YEAR+PCLASS+PASTSCR+GL1}$	7	-228.90	5.3

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 180 wetlands
[f] Sample size = 171 wetlands; sample size reduced to because PMAXHGT and PASTSCR were not available at all sites.

Appendix 5: Blackbird Nest Density models

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$BBND_{PCLASS+MAXHGT+CAI+CAI^2+WAREA}$	7	-192.04	0.00	0.6195
$BBND_{PCLASS+MAXHGT+CAI+WAREA}$	6	-190.53	1.51	0.2908
$BBND_{PCLASS+MAXHGT+CAI}$	5	-187.90	4.14	0.0782
$BBND_{CAI+MAXHGT}$	4	-181.94	10.10	0.0040
$BBND_{PCLASS+MAXHGT}$	4	-181.52	10.52	0.0032
$BBND_{PCLASS}$	3	-180.32	11.72	0.0018
$BBND_{PCLASS+COVER+WAREA}$	6	-180.21	11.83	0.0017
$BBND_{YEAR+PCLASS+COVER+WAREA}$	7	-178.05	13.99	0.0006
$BBND_{PCLASS+COVER}$	5	-176.17	15.87	0.0002
$BBND_{MAXHGT}$	3	-171.87	20.16	<0.0001
$BBND_{MAXHGT+MAXHGT^2}$	4	-171.03	21.01	<0.0001
$BBND_{CAI+CAI^2}$	4	-167.03	25.01	<0.0001
$BBND_{CAI}$	3	-166.18	25.85	<0.0001
$BBND_{WAREA}$	3	-166.14	25.90	<0.0001
$BBND_{NULL}$	2	-164.84	27.20	<0.0001
$BBND_{BARE+CAI}$	4	-164.68	27.36	<0.0001
$BBND_{WINTENSE}$	4	-164.23	27.81	<0.0001
$BBND_{YEAR}$	3	-163.14	28.90	<0.0001
$BBND_{DISTASP+DISTWET}$	4	-161.02	31.01	<0.0001
$BBND_{COVSHR+COVTRE}$	4	-160.86	31.17	<0.0001
$BBND_{BARE+NPLANT}$	4	-160.85	31.19	<0.0001
$BBND_{SQRTDISTASP+SQRTDISTWET}$	4	-160.81	31.23	<0.0001

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Pasture *a priori*[e]				
$BBND_{WDDENSE}$	3	-166.76	0.00	0.2455
$BBND_{PVGR+GRTYPE+WDDENSE}$	5	-165.86	0.90	0.1568
$BBND_{PVGR+WETDENSE+WDDENSE}$	5	-165.15	1.60	0.1100
$BBND_{NULL}$	2	-164.84	1.92	0.0941
$BBND_{PVGR}$	3	-164.76	2.00	0.0904
$BBND_{WETDENSE+PROPWET}$	4	-163.10	3.66	0.0394
$BBND_{CP}$	3	-163.08	3.67	0.0391
$BBND_{PVGR+PVGR^2}$	4	-162.77	3.99	0.0334
$BBND_{PVGR+GRTYPE}$	4	-162.72	4.04	0.0326
$BBND_{PINTENSE+GRTYPE+WDDENSE}$	6	-162.39	4.37	0.0277
$BBND_{PVGR+GRTYPE+WETDENSE}$	5	-161.89	4.87	0.0215
$BBND_{PINTENSE+GRTYPE}$	5	-161.60	5.16	0.0186
$BBND_{WETDENSE+PROPWET+WETDENSE*PROPWET}$	5	-161.13	5.62	0.0148
$BBND_{CP+GRTYPE}$	4	-161.05	5.71	0.0142
$BBND_{PVGR+GRTYPE+CP}$	5	-160.88	5.87	0.0130
$BBND_{PVGR+GRTYPE+PVGR*GRTYPE}$	5	-160.76	6.00	0.0122
$BBND_{PVGR+GRTYPE+WETDENSE+PROPWET}$	6	-160.40	6.36	0.0102
$BBND_{CP+GRTYPE+CP*GRTYPE}$	5	-160.23	6.53	0.0094
$BBND_{PINTENSE+GRTYPE+WETDENSE+PROPWET}$	7	-159.69	7.07	0.0072
$BBND_{PINTENSE+GRTYPE+CP}$	6	-159.64	7.11	0.0070
$BBND_{PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	7	-157.83	8.93	0.0028

Appendix 5: Cont.

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Landscape Effects[e]				
$BBND_{WO1}$	3	-166.33	0.00	0.2753
$BBND_{NULL}$	2	-164.84	1.50	0.1303
$BBND_{WO2}$	3	-163.24	3.09	0.0586
$BBND_{PC4}$	3	-163.15	3.18	0.0561
$BBND_{PC1}$	3	-162.94	3.39	0.0504
$BBND_{WO3}$	3	-162.94	3.40	0.0504
$BBND_{WO4}$	3	-162.87	3.46	0.0488
$BBND_{PC3}$	3	-162.86	3.47	0.0485
$BBND_{GL2}$	3	-162.86	3.48	0.0484
$BBND_{GL3}$	3	-162.80	3.53	0.0471
$BBND_{GL1}$	3	-162.79	3.54	0.0468
$BBND_{PC2}$	3	-162.78	3.55	0.0466
$BBND_{NORTH}$	3	-162.77	3.56	0.0464
$BBND_{GL4}$	3	-162.77	3.57	0.0463

Appendix 5: Cont.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Exploratory Multi-Level[e]				
$BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+WOI}$	8	-193.67	0.00	0.2214
$BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+WDDENSE+WOI}$	9	-192.29	1.37	0.1114
$BBND_{PCLASS+CAI+MAXHGT+WAREA+WOI}$	7	-192.17	1.50	0.1048
$BBND_{PCLASS+MAXHGT+CAI+CAI^2+WAREA}$	7	-192.04	1.63	0.0981
$BBND_{PCLASS+MAXHGT+CAI+CAI^2+WAREA+WDDENSE}$	8	-191.62	2.05	0.0795
$BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+GRTYPE+WDDENSE+WOI}$	10	-191.51	2.16	0.0753
$BBND_{PCLASS+CAI+MAXHGT+WAREA}$	6	-190.53	3.14	0.0461
$BBND_{PCLASS+MAXHGT+CAI+CAI^2}$	6	-190.34	3.33	0.0419
$BBND_{PCLASS+MAXHGT+CAI+WAREA+WDDENSE+WOI}$	8	-190.26	3.40	0.0404
$BBND_{PCLASS+MAXHGT+CAI+CAI^2+WDDENSE}$	7	-190.17	3.50	0.0386
$BBND_{PCLASS+MAXHGT+CAI+WAREA+WDDENSE}$	7	-189.30	4.36	0.0250
$BBND_{PCLASS+MAXHGT+CAI+WAREA+GRTYPE}$	7	-188.94	4.73	0.0208
$BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+PINTENSE+GRTYPE+WDDENSE+WOI}$	12	-188.72	4.94	0.0187
$BBND_{PCLASS+MAXHGT+CAI+WAREA+PVOR}$	7	-188.36	5.30	0.0156
$BBND_{PCLASS+MAXHGT+CAI+CAI^2+PVOR}$	7	-188.24	5.42	0.0147
$BBND_{PCLASS+MAXHGT+CAI+CAI^2+GRTYPE}$	7	-188.21	5.46	0.0145
$BBND_{PCLASS+MAXHGT+CAI+WDDENSE}$	6	-186.89	6.78	0.0075
$BBND_{PCLASS+MAXHGT+CAI+WAREA+GRTYPE+PVOR+WDDENSE}$	9	-186.81	6.86	0.0072
$BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+PINTENSE+GRTYPE+WDDENSE+PVOR+WOI}$	13	-186.80	6.87	0.0071
$BBND_{PCLASS+MAXHGT+CAI+GRTYPE}$	6	-186.01	7.65	0.0048
$BBND_{PCLASS+MAXHGT+CAI+PVOR}$	6	-185.76	7.90	0.0043
$BBND_{PCLASS+CAI+CAI^2+MAXHGT+WINTENSE+WAREA+PINTENSE+GRTYPE+WDDENSE+PVOR+WOI}$	15	-182.79	10.88	0.0010
$BBND_{PCLASS+MAXHGT+PVOR}$	5	-182.76	10.91	0.0009
$BBND_{PCLASS+MAXHGT+WDDENSE}$	5	-180.34	13.33	0.0003
$BBND_{PCLASS+MAXHGT+GRTYPE}$	5	-179.78	13.89	0.0002
$BBND_{NULL}$	2	-164.84	28.83	<0.0001
Substituted Variables[f]				
$BBND_{PCLASS+CAI+CAI^2+WVOR+WAREA+WOI}$	8	-133.37	0.00	
$BBND_{PCLASS+CAI+CAI^2+MAXHGT+WAREA+WOI}$	8	-129.70	3.49	

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 181 wetlands
[f] Sample size = 97 wetlands

Appendix 6: Blackbird Nest Daily Survival Models

Model	K^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Nest Site a-priori[e]				
$BB\text{-}DSR_{YEAR+DATE+DISTDRY}$	4	613.0	0.0	0.6686
$BB\text{-}DSR_{YEAR+DATE+NHGT+NDEPTH+DISTDRY}$	6	615.1	2.1	0.2340
$BB\text{-}DSR_{DATE+NDEPTH+DISTDRY+NHGT}$	5	617.2	4.2	0.0819
$BB\text{-}DSR_{DATE+DISTDRY}$	3	621.5	8.5	0.0095
$BB\text{-}DSR_{DATE+DISTDRY+NHGT}$	4	623.3	10.3	0.0039
$BB\text{-}DSR_{YEAR+DATE}$	3	626.0	13.0	0.0010
$BB\text{-}DSR_{YEAR+DATE+NCP}$	4	627.1	14.1	0.0006
$BB\text{-}DSR_{YEAR+DATE+NMAX}$	4	627.3	14.3	0.0005
$BB\text{-}DSR_{YEAR+DISTDRY}$	3	643.4	30.4	<0.0001
$BB\text{-}DSR_{YEAR+DISTDRY+NHGT}$	4	644.7	31.7	<0.0001
$BB\text{-}DSR_{YEAR+NDEPTH+DISTDRY+NHGT}$	5	646.3	33.3	<0.0001
$BB\text{-}DSR_{NHGT+NDEPTH+DISTDRY}$	4	658.4	45.4	<0.0001
$BB\text{-}DSR_{NHGT+NMAX}$	3	675.4	62.4	<0.0001
$BB\text{-}DSR_{NCP+DISTDRY}$	3	678.9	65.9	<0.0001
$BB\text{-}DSR_{NMAX}$	2	679.2	66.2	<0.0001
$BB\text{-}DSR_{NCP+NMAX}$	3	681.2	68.2	<0.0001
$BB\text{-}DSR_{NULL}$	1	681.8	68.8	<0.0001
$BB\text{-}DSR_{NCP}$	2	683.8	70.8	<0.0001

Appendix 6: Cont.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$BB\text{-}DSR_{BBNESTS+COVER+WET+SQRTDISTWET}$	6	610.4	0.0	0.6217
$BB\text{-}DSR_{BBNESTS+COVER+WET+SQRTDISTASP+SQRTDISTWET}$	7	611.4	1.0	0.3771
$BB\text{-}DSR_{PCLASS+COVER+BBNESTS+WET}$	6	623.5	13.1	0.0009
$BB\text{-}DSR_{BBNESTS+PCTOPEN+WET+SQRTDISTASP+SQRTDISTWET}$	6	625.5	15.1	0.0003
$BB\text{-}DSR_{BBNESTS+COVER+WET+COVTRE}$	5	631.5	21.1	<0.0001
$BB\text{-}DSR_{BBNESTS+COVER+WET+MAXHGT}$	6	633.5	23.1	<0.0001
$BB\text{-}DSR_{BBNESTS+COVER+WET+MAXHGT+TREND}$	7	633.7	23.3	<0.0001
$BB\text{-}DSR_{BBNESTS+WET}$	3	645.4	35.0	<0.0001
$BB\text{-}DSR_{BBNESTS+PCTOPEN+WET}$	4	646.3	35.9	<0.0001
$BB\text{-}DSR_{BBNESTS+PCTOPEN+WET+COVTRE}$	5	646.7	36.3	<0.0001
$BB\text{-}DSR_{COVER+SQRTDISTASP+SQRTDISTWET+COVSHB}$	6	648.1	37.7	<0.0001
$BB\text{-}DSR_{BBNESTS+PCTOPEN+WET+MAXHGT}$	5	648.3	37.9	<0.0001
$BB\text{-}DSR_{BBNESTS+PCTOPEN+WET+MAXHGT+TREND}$	8	648.7	38.3	<0.0001
$BB\text{-}DSR_{COVER+WET}$	4	652.2	41.8	<0.0001
$BB\text{-}DSR_{WET}$	2	655.7	45.3	<0.0001
$BB\text{-}DSR_{COVER}$	3	664.3	53.9	<0.0001
$BB\text{-}DSR_{BBNESTS}$	2	664.4	54.0	<0.0001
$BB\text{-}DSR_{PCLASS+COVER}$	4	665.9	55.5	<0.0001
$BB\text{-}DSR_{SQRTDISTWET}$	2	671.2	60.8	<0.0001
$BB\text{-}DSR_{DISTWET}$	2	676.7	66.3	<0.0001
$BB\text{-}DSR_{MAXHGT+TREND}$	3	679.3	68.9	<0.0001
$BB\text{-}DSR_{WAREA+PCTOPEN}$	3	680.3	69.9	<0.0001
$BB\text{-}DSR_{CAI}$	2	680.6	70.2	<0.0001
$BB\text{-}DSR_{COVSHB+COVTRE}$	3	680.7	70.3	<0.0001
$BB\text{-}DSR_{MAXHGT+TREND+MAXHGT*TREND}$	4	681.3	70.9	<0.0001
$BB\text{-}DSR_{NULL}$	1	681.8	71.4	<0.0001
$BB\text{-}DSR_{DISTASP}$	2	683.6	73.2	<0.0001
$BB\text{-}DSR_{SQRTDISTASP}$	2	683.7	73.3	<0.0001
$BB\text{-}DSR_{WINTENSE}$	3	684.9	74.5	<0.0001

Appendix 6: Cont.

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Pasture *a priori*[f]				
$BB\text{-}DSR_{PTREND+WETDENSE+PROPWET+WETDENSE*PROPWET+CP}$	6	611.6	0.0	0.5733
$BB\text{-}DSR_{PTREND+WETDENSE+PROPWET+WETDENSE*PROPWET}$	5	612.2	0.6	0.4247
$BB\text{-}DSR_{GRTYPE+PVOR+PTREND+WETDENSE+PROPWET}$	6	623.2	11.6	0.0017
$BB\text{-}DSR_{PVOR+PTREND}$	3	628.3	16.7	0.0001
$BB\text{-}DSR_{GRTYPE+PVOR+PTREND}$	4	630.0	18.4	0.0001
$BB\text{-}DSR_{WETDENSE+PROPWET+WETDENSE*PROPWET}$	4	635.4	23.8	<0.0001
$BB\text{-}DSR_{WETDENSE+PROPWET}$	3	635.8	24.2	<0.0001
$BB\text{-}DSR_{WETDENSE+PROPWET+WETDENSE*PROPWET+CP}$	5	637.1	25.5	<0.0001
$BB\text{-}DSR_{WETDENSE+PROPWET+WETDENSE*PROPWET}$	4	637.8	26.2	<0.0001
$BB\text{-}DSR_{WETDENSE}$	2	648.6	37.0	<0.0001
$BB\text{-}DSR_{NULL}$	1	648.7	37.1	<0.0001
$BB\text{-}DSR_{CP}$	2	649.1	37.5	<0.0001
$BB\text{-}DSR_{GRTYPE+PVOR+WETDENSE}$	4	650.0	38.4	<0.0001
$BB\text{-}DSR_{GRTYPE+PVOR}$	3	650.0	38.4	<0.0001
$BB\text{-}DSR_{WDDENSE}$	2	650.5	38.9	<0.0001
$BB\text{-}DSR_{WETDENSE+WDDENSE}$	3	650.6	39.0	<0.0001
$BB\text{-}DSR_{GRTYPE+PINTENSE}$	4	651.4	39.8	<0.0001

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Landscape Univariate Models[g]				
$BB\text{-}DSR_{WO4}$	2	659.8	0.0	0.5120
$BB\text{-}DSR_{WO3}$	2	660.6	0.8	0.3432
$BB\text{-}DSR_{WO2}$	2	662.8	3.0	0.1142
$BB\text{-}DSR_{WO1}$	2	665.7	5.9	0.0268
$BB\text{-}DSR_{NORTH}$	2	671.4	11.6	0.0016
$BB\text{-}DSR_{PC4}$	2	672.3	12.5	0.0010
$BB\text{-}DSR_{GL1}$	2	674.6	14.8	0.0003
$BB\text{-}DSR_{PC3}$	2	675.0	15.2	0.0003
$BB\text{-}DSR_{PC1}$	2	675.2	15.4	0.0002
$BB\text{-}DSR_{NULL}$	1	676.4	16.6	0.0001
$BB\text{-}DSR_{GL2}$	2	676.8	17.0	0.0001
$BB\text{-}DSR_{GL4}$	2	677.9	18.1	0.0001
$BB\text{-}DSR_{PC2}$	2	678.1	18.3	0.0001
$BB\text{-}DSR_{GL3}$	2	678.2	18.4	0.0001

Appendix 6: Cont.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Exploratory Models[g]				
BB-DSR$_{DATE+DISTDRY+NMAX+COVER+BBNESTS+WET+SQRTDISTWET+CAI}$	10	572.2	0.0	0.4560
BB-DSR$_{DATE+DISTDRY+NMAX+COVER+BBNESTS+WET+SQRTDISTWET}$	9	573.1	0.9	0.2908
BB-DSR$_{DATE+DISTDRY+NMAX+COVER+BBNESTS+WET+SQRTDISTWET+CAI+CP}$	11	573.4	1.2	0.2503
BB-DSR$_{DATE+DISTDRY+NMAX+COVER+BBNESTS+WET+SQRTDISTWET+CAI+PVOR}$	11	573.5	1.3	0.2381
BB-DSR$_{DATE+DISTDRY+NMAX+COVER+BBNESTS+SQRTDISTWET+CAI+PVOR}$	10	573.9	1.7	0.1949
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+COVER+WET+SQRTDISTASP+SQRTDISTWET+CAI+PVOR+CP+WO4}$	16	580.3	8.1	0.0079
BB-DSR$_{DATE+DISTDRY+NMAX+BBNESTS+WET+SQRTDISTWET+CAI+CP}$	9	580.6	8.4	0.0068
BB-DSR$_{DATE+DISTDRY+NMAX+BBNESTS+WET+SQRTDISTWET+CAI+CP+WO4}$	10	581.7	9.5	0.0039
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+COVER+WET+SQRTDISTASP+SQRTDISTWET+CAI+MAXHGT+PVOR+CP+WO4}$	17	582.3	10.1	0.0029
BB-DSR$_{DATE+DISTDRY+NMAX+BBNESTS+WET+SQRTDISTASP+SQRTDISTWET+CAI+CP+WO4}$	11	582.8	10.6	0.0023
BB-DSR$_{DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+WET+SQRTDISTASP+SQRTDISTWET+CAI+CP+WO4}$	12	584.7	12.5	0.0009
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+COVER+WINTENSE+WET+SQRTDISTASP+SQRTDISTWET+CAI+MAXHGT+PVOR+CP+WO4}$	19	586.1	13.9	0.0004
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+WET+SQRTDISTASP+SQRTDISTWET+CAI+CP+WO4}$	13	586.5	14.3	0.0004
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+COVER+WINTENSE+WET+SQRTDISTASP+SQRTDISTWET+CAI+MAXHGT+PVOR+WETDENSE+CP+WO4}$	20	588.2	16.0	0.0002
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+WET+SQRTDISTASP+SQRTDISTWET+CAI+PVOR+CP+WO4}$	14	588.5	16.3	0.0001
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+COVER+WINTENSE+WET+SQRTDISTASP+SQRTDISTWET+CAI+MAXHGT+TREND+PVOR+WETDENSE+CP+WO4}$	21	590.3	18.1	0.0001
BB-DSR$_{YEAR+DATE+NDEPTH+DISTDRY+NMAX+BBNESTS+COVER+WINTENSE+WET+SQRTDISTASP+SQRTDISTWET+CAI+MAXHGT+TREND+MAXHGT*TREND+PVOR+WETDENSE+CP+WO4}$	22	592.4	20.2	<0.0001
BB-DSR$_{NULL}$	1	676.4	104.2	<0.0001

[a] Number of parameters contained within model, includes intercept
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measure from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 581 nest intervals
[f] Sample size = 550 nest intervals
[g] Sample size = 576 nest intervals

Appendix 7: Other Songbird Nest Density models

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$OSND_{YEAR}$	3	215.99	0.0	0.2372
$OSND_{YEAR+CAI}$	4	217.80	1.8	0.0964
$OSND_{YEAR+PCLASS}$	4	217.91	1.9	0.0912
$OSND_{YEAR+WAREA}$	4	217.97	2.0	0.0884
$OSND_{YEAR+MAXDIST}$	4	218.05	2.1	0.0851
$OSND_{YEAR+WINTENSE}$	5	218.65	2.7	0.0629
$OSND_{YEAR+}$	5	219.59	3.6	0.0393
$OSND_{YEAR+COVERB+COVTRE}$	5	219.67	3.7	0.0377
$OSND_{YEAR+BARE+NPLANT}$	5	219.81	3.8	0.0353
$OSND_{YEAR+CAI+CAI^2}$	5	219.86	3.9	0.0344
$OSND_{YEAR+BARE+CAI}$	5	219.90	3.9	0.0337
$OSND_{YEAR+CAI+MAXDIST}$	5	219.90	3.9	0.0336
$OSND_{YEAR+PCLASS+MAXDIST}$	5	220.01	4.0	0.0318
$OSND_{YEAR+MAXDIST+MAXDIST^2}$	5	220.08	4.1	0.0308
$OSND_{YEAR+}$	5	220.20	4.2	0.0290
$OSND_{YEAR+PCLASS+MAXDIST+CAI}$	6	221.80	5.8	0.0130
$OSND_{YEAR+PCLASS+COVER}$	6	222.08	6.1	0.0113
$OSND_{YEAR+PCLASS+}$	7	223.85	7.9	0.0047
$OSND_{YEAR+PCLASS+COVER+WAREA}$	7	224.09	8.1	0.0041
$OSND_{NULL}$	2	235.82	19.8	<0.0001

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Pasture *a priori*[e]				
$OSND_{}$	7	227.50	0.0	0.8851
$OSND_{}$	5	234.65	7.2	0.0248
$OSND_{}$	6	234.92	7.4	0.0218
$OSND_{NULL}$	2	235.82	8.3	0.0139
$OSND_{}$	3	235.97	8.5	0.0128
$OSND_{}$	6	236.69	9.2	0.0089
$OSND_{CP}$	3	237.60	10.1	0.0057
$OSND_{PVGR}$	3	237.87	10.4	0.0050
$OSND_{}$	5	238.50	11.0	0.0036
$OSND_{}$	7	238.62	11.1	0.0034
$OSND_{}$	4	239.35	11.8	0.0024
$OSND_{}$	4	239.63	12.1	0.0021
$OSND_{}$	4	239.75	12.2	0.0019
$OSND_{}$	4	239.83	12.3	0.0019
$OSND_{}$	5	239.84	12.3	0.0019
$OSND_{}$	5	240.17	12.7	0.0016
$OSND_{}$	5	240.66	13.2	0.0012
$OSND_{}$	5	241.17	13.7	0.0010
$OSND_{}$	5	241.35	13.9	0.0009
$OSND_{}$	6	243.48	16.0	0.0003

Appendix 7: Cont.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Landscape Effects[e]				
$OSND_{WO4}$	3	234.83	0.0	0.1625
$OSND_{WO3}$	3	235.08	0.2	0.1435
$OSND_{NULL}$	2	235.82	1.0	0.0992
$OSND_{WO2}$	3	235.88	1.0	0.0963
$OSND_{NORTH}$	3	236.61	1.8	0.0666
$OSND_{PC1}$	3	236.90	2.1	0.0576
$OSND_{PC4}$	3	236.99	2.2	0.0552
$OSND_{WO1}$	3	237.00	2.2	0.0550
$OSND_{GL3}$	3	237.18	2.4	0.0501
$OSND_{PC3}$	3	237.24	2.4	0.0487
$OSND_{GL4}$	3	237.35	2.5	0.0460
$OSND_{PC2}$	3	237.50	2.7	0.0428
$OSND_{GL2}$	3	237.67	2.8	0.0394
$OSND_{GL1}$	3	237.79	3.0	0.0371

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Exploratory Multi-Level[e]				
$OSND_{YEAR+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$	9	202.34	0.0	0.2525
$OSND_{YEAR+PCLASS+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$	10	203.10	0.8	0.1726
$OSND_{YEAR+PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	8	204.10	1.8	0.1045
$OSND_{YEAR+WAREA+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$	10	204.41	2.1	0.0895
$OSND_{YEAR+CAI+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$	10	204.56	2.2	0.0830
$OSND_{YEAR+PCLASS+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WDDENSE+WO4}$	11	204.92	2.6	0.0694
$OSND_{YEAR+PCLASS+PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	9	205.22	2.9	0.0598
$OSND_{YEAR+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WDDENSE}$	9	205.39	3.1	0.0549
$OSND_{YEAR+WAREA+PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	9	206.00	3.7	0.0404
$OSND_{YEAR+CAI+PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	9	206.28	3.9	0.0351
$OSND_{YEAR+PINTENSE+GRTYPE+PINTENSE*GRTYPE+MAXHGT}$	9	206.30	4.0	0.0348
$OSND_{YEAR+CAI+PCLASS+WAREA+CAI^2+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WDDENSE+WO4}$	14	211.39	9.1	0.0027
$OSND_{YEAR\ (NULL)}$	2	213.93	11.6	0.0008
$OSND_{PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$	8	226.17	23.8	<0.0001
$OSND_{CAI+PINTENSE+GRTYPE+PINTENSE*GRTYPE+WO4}$	9	228.37	26.0	<0.0001
$OSND_{CAI+PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	8	229.48	27.1	<0.0001

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 181 wetlands

Appendix 8: Other Songbird Nest Daily Survival Models

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Nest Site a-priori[e]				
$OS\text{-}DSR_{YEAR+DATE}$	3	178.5	0.0	0.8023
$OS\text{-}DSR_{NMAX}$	2	183.4	4.9	0.0692
$OS\text{-}DSR_{NULL}$	1	183.5	5.0	0.0659
$OS\text{-}DSR_{NCP}$	2	183.6	5.1	0.0626

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Wetland *a priori*[e]				
$OS\text{-}DSR_{PCLASS+COVER}$	4	176.9	0.0	0.6940
$OS\text{-}DSR_{MAXHGT+WTREND+MAXHGT*WTREND}$	4	180	3.1	0.1473
$OS\text{-}DSR_{MAXHGT+WTREND}$	3	182.4	5.5	0.0444
$OS\text{-}DSR_{WAREA+PCTOPEN}$	3	182.9	6.0	0.0346
$OS\text{-}DSR_{NULL}$	1	183.5	6.6	0.0256
$OS\text{-}DSR_{WET}$	2	185.0	8.1	0.0121
$OS\text{-}DSR_{CAI}$	2	185.2	8.3	0.0109
$OS\text{-}DSR_{MAXHGT+MAXHGT^2}$	3	185.4	8.5	0.0099
$OS\text{-}DSR_{DISTASP+DISTWET}$	3	186.1	9.2	0.0070
$OS\text{-}DSR_{COVSHB+COVTRE}$	3	186.5	9.6	0.0057
$OS\text{-}DSR_{SQRTDISTASP+SQRTDISTWET}$	3	186.9	10.0	0.0047
$OS\text{-}DSR_{WINTENSE}$	3	187.3	10.4	0.0038

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Pasture *a priori*[e]				
$OS\text{-}DSR_{PINTENSE}$	3	183.1	0.0	0.2185
$OS\text{-}DSR_{NULL}$	1	183.5	0.4	0.1789
$OS\text{-}DSR_{WETDENSE}$	2	183.6	0.5	0.1702
$OS\text{-}DSR_{PVOR+PVOR^2}$	3	183.8	0.7	0.1540
$OS\text{-}DSR_{WDDENSE}$	2	184.7	1.6	0.0982
$OS\text{-}DSR_{GRTYPE+PINTENSE}$	4	184.9	1.8	0.0889
$OS\text{-}DSR_{CP}$	2	185.5	2.4	0.0658
$OS\text{-}DSR_{GRTYPE+PVOR}$	3	187.4	4.3	0.0255

Appendix 8: Cont.

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Landscape Univariate[e]				
OS -DSR_{NULL}	1	183.5	0.0	0.1225
OS -DSR_{GL1}	2	183.6	0.1	0.1165
OS -DSR_{NORTH}	2	183.9	0.4	0.1003
OS -DSR_{PC1}	2	184.2	0.7	0.0863
OS -DSR_{GL4}	2	184.2	0.7	0.0863
OS -DSR_{WD1}	2	184.4	0.9	0.0781
OS -DSR_{GL3}	2	184.8	1.3	0.0640
OS -DSR_{PC4}	2	184.9	1.4	0.0608
OS -DSR_{PC3}	2	185.1	1.6	0.0551
OS -DSR_{GL2}	2	185.4	1.9	0.0474
OS -DSR_{WD4}	2	185.4	1.9	0.0474
OS -DSR_{PC2}	2	185.5	2.0	0.0451
OS -DSR_{WD2}	2	185.5	2.0	0.0451
OS -DSR_{WD3}	2	185.5	2.0	0.0451

Appendix 8: Cont.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Exploratory Analysis[e]				
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+CAI+WTREND+PINTENSE}$	8	167.7	0.0	0.3666
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND+PINTENSE}$	7	168.9	1.2	0.2012
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE}$	9	170.0	2.3	0.1161
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+GRTYPE+PCLASS+COVER+MAXHGT+GL1}$	15	170.8	3.1	0.0778
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND+PINTENSE+PCLASS+MAXHGT+GL1+PVOR+PVOR^2}$	12	171.7	4.0	0.0496
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+GRTYPE}$	10	172.2	4.5	0.0386
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+GRTYPE+PCLASS+COVER+MAXHGT+WAREA+GL1}$	16	173.1	5.4	0.0246
$OS\text{-}DSR_{DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+PCLASS+MAXHGT+GL1+PVOR+PVOR^2}$	13	173.9	6.2	0.0165
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+PCLASS+MAXHGT+GL1+PVOR+PVOR^2}$	14	173.9	6.2	0.0165
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+GRTYPE+PCLASS+COVER+MAXHGT+GL1+PVOR+PVOR^2}$	17	174.8	7.1	0.0105
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+GRTYPE+PCLASS+COVER+GL1}$	12	174.8	7.1	0.0105
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PCLASS+GL1}$	9	175.4	7.7	0.0078
$OS\text{-}DSR_{PCTOPEN+CAI+WTREND+PCLASS+GL1}$	6	175.8	8.1	0.0064
$OS\text{-}DSR_{PCTOPEN+CAI+WTREND+GL1}$	5	175.8	8.1	0.0064
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+GRTYPE+PCLASS+MAXHGT+GL1+PVOR+PVOR^2}$	15	175.8	8.1	0.0064
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND+MAXHGT+GL1+PVOR+PVOR^2}$	9	175.9	8.2	0.0061
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND+PCLASS+GL1}$	7	176.2	8.5	0.0052
$OS\text{-}DSR_{DATE+PCTOPEN+WTREND}$	4	176.2	8.5	0.0052
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND}$	5	176.8	9.1	0.0039
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+GRTYPE+PCLASS+COVER+MAXHGT+GL1}$	13	177.0	9.3	0.0035
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PINTENSE+GRTYPE+PCLASS+COVER+MAXHGT+WAREA+GL1+PVOR+PVOR^2}$	18	177.0	9.3	0.0035
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND+MAXHGT+PVOR+PVOR^2}$	8	177.2	9.5	0.0032
$OS\text{-}DSR_{YEAR+DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+GRTYPE+PCLASS+GL1}$	10	177.2	9.5	0.0032
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND+PCLASS+MAXHGT+GL1+PVOR+PVOR^2}$	10	177.6	9.9	0.0026
$OS\text{-}DSR_{PCTOPEN+CAI+WTREND}$	4	177.9	10.2	0.0022
$OS\text{-}DSR_{DATE+PCTOPEN+SQRTDISTASP+CAI+WTREND+PCLASS+GL1}$	8	178.1	10.4	0.0020
$OS\text{-}DSR_{DATE+PCTOPEN+CAI+WTREND+MAXHGT}$	6	178.3	10.6	0.0018
$OS\text{-}DSR_{PCTOPEN+WTREND}$	3	178.5	10.8	0.0017
$OS\text{-}DSR_{NULL}$	1	183.5	15.8	0.0001

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 271 nest intervals

Appendix 9: Waterbird Nest Density Models

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$WBND_{PCLASS+CAI+CAI^2}$	5	192.28	0.0	0.2049
$WBND_{PCLASS+CAI}$	4	192.45	0.2	0.1874
$WBND_{PCLASS}$	3	193.47	1.2	0.1126
$WBND_{PCLASS+COVER}$	5	193.50	1.2	0.1111
$WBND_{PCLASS+MAXHGT+CAI}$	5	193.84	1.6	0.0938
$WBND_{PCLASS+COVER+WAREA}$	6	195.33	3.0	0.0446
$WBND_{PCLASS+MAXHGT}$	4	195.56	3.3	0.0397
$WBND_{PCLASS+MAXHGT+CAI+WAREA}$	6	195.62	3.3	0.0385
$WBND_{CAI+CAI^2}$	4	196.25	4.0	0.0280
$WBND_{CAI}$	3	196.30	4.0	0.0274
$WBND_{CAI+MAXHGT}$	4	196.36	4.1	0.0266
$WBND_{YEAR+PCLASS+COVER+WAREA}$	7	197.09	4.8	0.0185
$WBND_{NULL}$	2	197.47	5.2	0.0152
$WBND_{BARE+CAI}$	4	198.37	6.1	0.0097
$WBND_{WINTENSE}$	4	198.70	6.4	0.0082
$WBND_{WAREA}$	3	198.99	6.7	0.0071
$WBND_{MAXHGT}$	3	199.09	6.8	0.0068
$WBND_{YEAR}$	3	199.34	7.1	0.0060
$WBND_{BARE+NPLANT}$	4	200.48	8.2	0.0034
$WBND_{SQRTDISTASP+SQRTDISTWET}$	4	200.82	8.5	0.0029
$WBND_{MAXHGT+MAXHGT^2}$	4	201.12	8.8	0.0025
$WBND_{DISTASP+DISTWET}$	4	201.14	8.9	0.0024
$WBND_{COVSHB+COVTRE}$	4	201.21	8.9	0.0024

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Pasture *a priori*[e]				
$WBND_{PINTENSE+GRTYPE+WDDENSE}$	6	192.12	0.0	0.4331
$WBND_{PVOR+GRTYPE+WDDENSE}$	5	193.14	1.0	0.2608
$WBND_{WDDENSE}$	3	194.42	2.3	0.1371
$WBND_{NULL}$	2	197.47	5.3	0.0299
$WBND_{PINTENSE+GRTYPE}$	5	197.55	5.4	0.0288
$WBND_{CP}$	3	198.27	6.1	0.0201
$WBND_{PVOR}$	3	199.47	7.3	0.0110
$WBND_{CP+GRTYPE}$	4	199.48	7.4	0.0109
$WBND_{PINTENSE+GRTYPE+WETDENSE+PROPWET}$	7	199.54	7.4	0.0106
$WBND_{PINTENSE+GRTYPE+CP}$	6	199.68	7.6	0.0099
$WBND_{PVOR+GRTYPE+PVOR*GRTYPE}$	5	200.39	8.3	0.0069
$WBND_{PVOR+GRTYPE}$	4	200.40	8.3	0.0069
$WBND_{WETDENSE+PROPWET}$	4	200.68	8.6	0.0060
$WBND_{PINTENSE+GRTYPE+PINTENSE*GRTYPE}$	7	200.79	8.7	0.0057
$WBND_{GRAZE+GRTYPE+CP*GRTYPE}$	5	201.17	9.0	0.0047
$WBND_{PVOR+PVOR^2}$	4	201.31	9.2	0.0044
$WBND_{PVOR+GRTYPE+CP}$	5	201.51	9.4	0.0040
$WBND_{PVOR+GRTYPE+WETDENSE}$	5	201.92	9.8	0.0032
$WBND_{PVOR+WETDENSE+WDDENSE}$	5	202.60	10.5	0.0023
$WBND_{WETDENSE+PROPWET+WETDENSE*PROPWET}$	5	202.68	10.6	0.0022
$WBND_{PVOR+GRTYPE+WETDENSE+PROPWET}$	6	203.42	11.3	0.0015

Appendix 9: Cont.

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Landscape Effects[e]				
$WBND_{WO1}$	3	194.39	0.0	0.3026
$WBND_{GL1}$	3	194.90	0.5	0.2343
$WBND_{GL2}$	3	197.31	2.9	0.0704
$WBND_{NULL}$	2	197.47	3.1	0.0647
$WBND_{GL4}$	3	197.97	3.6	0.0506
$WBND_{WO2}$	3	198.30	3.9	0.0428
$WBND_{GL3}$	3	198.35	4.0	0.0417
$WBND_{NORTH}$	3	199.02	4.6	0.0298
$WBND_{WO3}$	3	199.03	4.6	0.0297
$WBND_{WO4}$	3	199.08	4.7	0.0290
$WBND_{PC4}$	3	199.09	4.7	0.0288
$WBND_{PC3}$	3	199.30	4.9	0.0259
$WBND_{PC1}$	3	199.38	5.0	0.0249
$WBND_{PC2}$	3	199.40	5.0	0.0247

Appendix 9: Cont.

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Exploratory Multi-Level[e]				
$WBND_{PCLASS+CAI+CAI^2+GRTYPE+WDDENSE}$	7	187.13	0.0	0.2739
$WBND_{PCLASS+WDDENSE+GRTYPE}$	5	188.88	1.8	0.1138
$WBND_{PCLASS+CAI+CAI^2+PINTENSE+GRTYPE+WDDENSE}$	9	189.18	2.1	0.0982
$WBND_{PCLASS+WDDENSE+CAI+CAI^2}$	6	189.42	2.3	0.0869
$WBND_{PCLASS+CAI+CAI^2+PINTENSE+GRTYPE+WDDENSE+GLI}$	10	191.22	4.1	0.0354
$WBND_{WDDENSE+GRTYPE}$	4	191.25	4.1	0.0348
$WBND_{PCLASS+WDDENSE+CAI}$	5	191.37	4.2	0.0327
$WBND_{PCLASS+WDDENSE+PINTENSE}$	6	191.51	4.4	0.0306
$WBND_{PCLASS+WDDENSE}$	4	192.22	5.1	0.0214
$WBND_{PCLASS+PINTENSE}$	5	192.23	5.1	0.0214
$WBND_{PCLASS+WDDENSE+COVER}$	6	192.26	5.1	0.0210
$WBND_{PCLASS+CAI}$	4	192.45	5.3	0.0191
$WBND_{PCLASS+WDDENSE+CP}$	5	192.50	5.4	0.0186
$WBND_{PCLASS+WOI}$	4	192.68	5.6	0.0171
$WBND_{PCLASS+WDDENSE+WOI}$	5	192.97	5.8	0.0147
$WBND_{PCLASS+WDDENSE+WINTENSE}$	6	193.08	6.0	0.0140
$WBND_{WDDENSE+CAI}$	4	193.37	6.2	0.0121
$WBND_{PCLASS+CAI+CAI^2+PINTENSE+GRTYPE+WDDENSE+WOI+GLI}$	11	193.47	6.3	0.0115
$WBND_{PCLASS+WDDENSE+WAREA}$	5	193.80	6.7	0.0097
$WBND_{WDDENSE+WOI}$	4	193.89	6.8	0.0093
$WBND_{PCLASS+GRTYPE}$	4	193.91	6.8	0.0092
$WBND_{PCLASS+CP}$	4	193.92	6.8	0.0092
$WBND_{PCLASS+WDDENSE+PCTOPEN}$	5	193.99	6.9	0.0089
$WBND_{PCLASS+WDDENSE+DISTWET}$	5	194.25	7.1	0.0078
$WBND_{WDDENSE+PINTENSE}$	5	194.28	7.2	0.0077
$WBND_{WDDENSE+PINTENSE}$	5	194.28	7.2	0.0077
$WBND_{PCLASS+WDDENSE+PVOR}$	5	194.29	7.2	0.0076
$WBND_{PCLASS+WDDENSE+DISTASP}$	5	194.31	7.2	0.0075
$WBND_{PCLASS+WINTENSE}$	5	194.32	7.2	0.0075
$WBND_{PCLASS+WDDENSE+MAXHGT}$	5	194.33	7.2	0.0075
$WBND_{WDDENSE+CP}$	4	194.96	7.8	0.0055
$WBND_{PCLASS+PVOR}$	4	195.46	8.3	0.0042
$WBND_{PCLASS+MAXHGT}$	4	195.56	8.4	0.0040
$WBND_{WDDENSE+MAXHGT}$	4	196.26	9.1	0.0028
$WBND_{PCLASS+WDDENSE+MAXHGT+MAXHGT^2}$	6	196.40	9.3	0.0027
$WBND_{WDDENSE+PVOR}$	4	196.49	9.4	0.0025
$WBND_{NULL}$	2	197.47	10.3	0.0016

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 181 wetlands

Appendix 10: Waterbird Nest Daily Survival Models

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Nest Site a-priori[e]				
$WB\text{-}DSR_{YEAR+DATE}$	3	279.8	0.0	0.8504
$WB\text{-}DSR_{NTYPE}$	2	283.9	4.1	0.1095
$WB\text{-}DSR_{NULL}$	1	287.6	7.8	0.0172
$WB\text{-}DSR_{NCP}$	2	287.8	8.0	0.0156
$WB\text{-}DSR_{NMAX}$	2	289.3	9.5	0.0074

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Wetland *a priori*[e]				
$WB\text{-}DSR_{PCLASS+COVER}$	4	276.8	0.0	0.4770
$WB\text{-}DSR_{WAREA+PCTOPEN}$	3	277.0	0.2	0.4316
$WB\text{-}DSR_{WET}$	2	280.7	3.9	0.0679
$WB\text{-}DSR_{SQRTDISTASP+SQRTDISTWET}$	3	285.7	8.9	0.0056
$WB\text{-}DSR_{CAI+CAI^2}$	3	285.8	9.0	0.0053
$WB\text{-}DSR_{CAI}$	2	286.3	9.5	0.0041
$WB\text{-}DSR_{WINTENSE}$	3	286.5	9.7	0.0037
$WB\text{-}DSR_{NULL}$	1	287.6	10.8	0.0022
$WB\text{-}DSR_{DISTASP+DISTWET}$	3	289.3	12.5	0.0009
$WB\text{-}DSR_{MAXHGT+TREND}$	3	289.6	12.8	0.0008
$WB\text{-}DSR_{COVSHB+COVTRE}$	3	291.1	14.3	0.0004
$WB\text{-}DSR_{MAXHGT+TREND+MAXHGT*TREND}$	4	291.4	14.6	0.0003
$WB\text{-}DSR_{MAXHGT+MAXHGT^2}$	3	291.6	14.8	0.0003

Model	k[a]	AIC_c[b]	ΔAIC_c[c]	ω_i[d]
Pasture *a priori*[f]				
$WB\text{-}DSR_{PVOR+PVOR^2}$	3	264.0	0.0	0.6926
$WB\text{-}DSR_{WETDENSE+PROPWET+WETDENSE*PROPWET}$	4	267.2	3.2	0.1398
$WB\text{-}DSR_{GRTYPE+PVOR}$	3	268.0	4.0	0.0937
$WB\text{-}DSR_{GRTYPE+PVOR+PTREND}$	4	270.1	6.1	0.0328
$WB\text{-}DSR_{GRTYPE+PVOR+PTREND+PVOR*PTREND}$	5	271.0	7.0	0.0209
$WB\text{-}DSR_{NULL}$	1	272.9	8.9	0.0081
$WB\text{-}DSR_{WDDENSE}$	2	274.6	10.6	0.0035
$WB\text{-}DSR_{CP}$	2	274.9	10.9	0.0030
$WB\text{-}DSR_{WETDENSE}$	2	274.9	10.9	0.0030
$WB\text{-}DSR_{GRTYPE+PINTENSE}$	4	275.1	11.1	0.0027

Appendix 10: Cont.

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Landscape Univariate[g]				
WB-DSR$_{PC4}$	2	279.9	0.0	0.3409
WB-DSR$_{PC3}$	2	281.6	1.7	0.1457
WB-DSR$_{PC2}$	2	282.2	2.3	0.1079
WB-DSR$_{WO4}$	2	283.4	3.5	0.0592
WB-DSR$_{WO3}$	2	283.7	3.8	0.0510
WB-DSR$_{NULL}$	1	283.9	4.0	0.0461
WB-DSR$_{WO2}$	2	284.0	4.1	0.0439
WB-DSR$_{NORTH}$	2	284.3	4.4	0.0378
WB-DSR$_{WO1}$	2	284.4	4.5	0.0359
WB-DSR$_{PC1}$	2	284.4	4.5	0.0359
WB-DSR$_{GL4}$	2	284.9	5.0	0.0280
WB-DSR$_{GL1}$	2	285.2	5.3	0.0241
WB-DSR$_{GL3}$	2	285.3	5.4	0.0229
WB-DSR$_{GL2}$	2	285.5	5.6	0.0207

Model	k^a	AIC_c^b	ΔAIC_c^c	ω_i^d
Exploratory Analysis[f]				
WB-DSR$_{NTYPE+COVER+WAREA+PVOR}$	6	257.1	0.0	0.2174
WB-DSR$_{COVER+WAREA+PVOR+PVOR^2+NTYPE}$	7	257.8	0.7	0.1532
WB-DSR$_{NTYPE+COVER+WAREA+PVOR+PROPWET}$	7	259.2	2.1	0.0761
WB-DSR$_{PCTOPEN+WAREA+PVOR+PVOR^2}$	5	259.4	2.3	0.0689
WB-DSR$_{JUDTST+NTYPE+COVER+WAREA+PVOR+PVOR^2+GRTYPEN}$	9	259.5	2.4	0.0655
WB-DSR$_{COVER+WAREA+PVOR+PVOR^2}$	6	259.6	2.5	0.0623
WB-DSR$_{NTYPE+WAREA+PVOR+PVOR^2}$	5	259.6	2.5	0.0623
WB-DSR$_{COVER+WAREA+PVOR}$	5	259.7	2.6	0.0593
WB-DSR$_{WAREA+PVOR+PVOR^2}$	4	259.7	2.6	0.0593
WB-DSR$_{NTYPE+WAREA+PVOR}$	4	259.9	2.8	0.0536
WB-DSR$_{PCTOPEN+WAREA+PVOR}$	4	259.9	2.8	0.0536
WB-DSR$_{WAREA+PVOR}$	3	260.5	3.4	0.0397
WB-DSR$_{NTYPE+COVER+WAREA+PVOR+WETDENSE+PROPWET+WETDENSE*PROPWET}$	9	262.9	5.8	0.0120
WB-DSR$_{JUDTST+NTYPE+COVER+WAREA+CAI+CAI^2+PVOR+PVOR^2+GRTYPEN}$	11	263.1	6.0	0.0108
WB-DSR$_{NTYPE+COVER+WAREA+WET+PVOR+WETDENSE+PROPWET+WETDENSE*PROPWET}$	10	264.3	7.2	0.0059
WB-DSR$_{NULL}$	1	272.9	15.8	0.0001

[a] Number of parameters contained within model, includes intercept and dispersion.
[b] Akaike Information Criterion score corrected for small sample size
[c] Difference in AIC_c scores measured from lowest AIC_c score within suite
[d] Akaike model weights (within suite)
[e] Sample size = 233 nest intervals
[f] Sample size = 222 nest intervals
[g] Sample size = 229 nest intervals